Summary of Research

Introduction

Emergency and Urgent care (EUC) is a major international issue. This study will address EUC from the point of an ambulance being called through to admission, and/or transfer out from hospital, focussing upon interventions in the Emergency Department for older people. Older people with EUC needs, in particular those with frailty, are especially vulnerable to harms that can arise in this care pathway. The first hours of an EUC episode can have a powerful influence; for example, the early identification of delirium should lead to more assertive treatment (e.g. intravenous instead of oral therapy), early mobilisation and a review of potentially harmful medication (anticholinergics). Evidence based solutions are required, but it is unlikely that there is one single optimal care model given the various contexts. Rather, there will be a range of possible solutions, with overarching principles that can be specified. We will undertake a series of linked studies, with a focus on implementation, which will provide robust, practical and focussed user-guidance about how best to organise the care pathway in Emergency Departments, so as to improve outcomes for older people with EUC needs. We will conduct an evidence synthesis, in-depth stakeholder interviews, analysis of patient pathways and outcomes, and sophisticated modelling of complex systems.

Methods

Workpackage 1 – identifying best practice

WP1.1 review of reviews of EUC interventions for older people, their outcomes and costs and any implementation factors identified.

WP1.2 interviews of older people and their carers with recent experience of EUC, using the findings to ensure that the patient's voice is at the centre of this study.

WP1.3 clinician interviews about emerging interventions and key elements of high quality care.

Workpackage 2 – qualitative study of delivery of exemplar EUC pathways

Qualitative fieldwork (interviews, ethnography, documentary analysis) in 4-6 sites exemplifying promising pathways, to identify aspects relevant to transfer and adaptation of these models to other settings.

Workpackage 3 – routine patient level data analysis to describe EUC pathways, outcomes and costs

Analysis of linked databases to describe EUC pathways experienced by people aged 75+ across the Yorkshire and Humber region, 2010-2017. The aims are to assess which pathways deliver better patient outcomes than others, how pathways have changed over time, and what patient characteristics, demand factors and supply factors explain differences in outcomes and costs between patients, from place to place, and over time.

Workpackage 4 – modelling improvements to EUC pathways

We will develop a family of System Dynamics (SD) computer simulation models representing patient flow through the entire care process for different EUC pathways, using evidence from WP1 and WP2 and data from WP3. We will use these models to evaluate EUC interventions in different settings, in terms of their impact on patient outcomes and their knock-on effects in the wider care system.

PPI

PPI input will include high level strategic oversight of the study progress, assured by quarterly briefings to the PPI leads at the Executive Management Team meetings, complimented by 'deep dive' reviews of specific aspects of the project (for example scrutinising recruitment plans and interview schedules); quarterly consultations with the broader Leicester PPI forum to bring wider perspectives to the research; and focussed interaction with the East Midlands Centre for Ethnic Health Research.

Dissemination

We will involve an existing, established national stakeholder group focussing on urgent care of older people with frailty. A comprehensive dissemination strategy (including evidence summaries, high impact papers, national and international conferences, press releases, and national dissemination events) will be developed and targeted to key audiences who will be interested in the findings of this research, informed by the stakeholder group.

Impact

The primary output will be a validated, patient-centred, System Dynamics model(s) adaptable to all health care systems through an easy to use interface, allowing modelling of emergency department interventions on the whole system.

In addition, we will provide outputs relevant to teams planning and delivering EUC for older people, and to academics. These will include a user-friendly classification of the different types of care pathway, summarising the strengths and limitations of different approaches and key points of information about optimising their delivery.

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The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.

Background and Rationale

Emergency and Urgent care (EUC) is a major international issue. For example in July 2017, only 15/138 (11%) of type 1 Emergency Departments (EDs) in England achieved the emergency care standard (a national target which aims to see and transfer 95% of ED attendees within four hours) – and performance has been deteriorating for several years[1]. Older people with EUC needs, in particular those with frailty, are especially vulnerable to harms and delays that can arise in this system, and the first hours have a powerful influence over the remaining EUC episode[2-5]. For example, the failure to identify delirium (new onset confusion, often with a significant underlying medical cause, which leads to reduced attention, poor oral intake and reduced mobility) can result in harms accruing in the first hours of the patient journey (e.g. dehydration, pressure sores), which add to the primary presenting problem – so called 'deconditioning[6, 7].

It is not only the admitted population of older people who are at risk - those discharged from EDs are also at risk of significant functional decline in the months following their attendance[8]. There is a need to improve the management of both of these patient groups in order to optimise their time in the EUC system, reduce complications and avoid unnecessary investigations and admission to hospital. This might involve a move away from 'one problem, one solution' approaches, which historically typifies emergency care, towards a more nuanced approach that takes account of multiple comorbidities, initial evaluations of which appear to show some promise in emergency care settings[9].

Demand for EUC is rising annually, especially in older people, who form one fifth of attendees at EDs[10]. Our own analysis of 1.3 million attendances at 18 EDs in Yorkshire and Humber has shown that two-thirds of patients over the age of 75 year arrive by ambulance, patients over 75 spend significantly longer in the ED, and are referred for admission over half of the time[11]. But we also found significant variation in admission rates by hospital studied (18-73%) in older people, which could not be fully explained by case mix. Understanding the range of variation in practice that lead to different admission rates and how this can be reduced would be timely and beneficial to health services.

Evidence explaining why this research is needed now

The increased use of EUC has been linked with many factors including the complexity of case mix (comorbidities, social and mental health problems), often associated with older people. There have also been changes in the options available to patients, professional opinions on appropriate treatment and the capacity of individual care systems. This has led to making care of frail older people an urgent public health problem, both nationally and internationally.

The management of older people in the EUC system remains sub-optimal, despite efforts by organisations such as the British Geriatrics Society and the Royal College of Emergency Medicine in publishing guidance on the topic[12]. Strategies are needed to manage older patients sensitively, effectively and efficiently, both understanding the clinical as well as social and family/carer needs. It may be that by adopting novel approaches closer to the hospital 'front door', the care and outcomes

of these patients can be optimised. Such models might not only improve outcomes for older people, but for the broader EUC system. For example, admission avoidance services focussing on older people in the ED have been shown to reduce admissions, but also have added benefits for the whole hospital through reduced bed-occupancy[9], including improvements in the four hour standard[13].

There is good evidence that frail older patients on acute wards benefit from interventions such as Comprehensive Geriatric Assessment[14], which may be an approach that should also be considered for the ED. We have identified 10 studies addressing care for older patients in the ED, but this evidence is of low quality, often from small, single centre studies and to date has not shown consistent evidence of benefit on the chosen outcomes[15-25]. Moreover, the context in EUC is very different from geriatric wards; EDs are busier, with time targets of hours rather than days, and require a 24/7 response for patients. The ED currently represents a research 'black hole' in relation to older people's care and there is an urgent need for research in order to improve the care of this growing group of patients that addresses their specific needs and those of the healthcare professionals managing them in the ED environment. The Royal College of Emergency Medicine recently undertook a James Lind facilitated research prioritisation exercise, which ranked care of older people with frailty in Emergency Departments (EDs) as two of the top 10 research priorities.

The implementation of novel approaches to caring for frail older people need to be seen within the context of the complex array of different services models currently offered for EUC. It is therefore important that any new approaches are based on robust research evidence, and their implementation is evaluated in terms of clinical and cost-effectiveness as well as understanding the impact for organisations and patients themselves. Such assessment needs to make the most of available data flows and modern approaches to understanding how patients move through care systems and the impact on effectiveness and efficiency. This proposal makes use of existing data, modelling, qualitative enquiry and patient participation to describe the essential elements of a complex intervention, in keeping with the MRC guidance[26].

Aims and objectives

We aim to identify promising care models and guidance derived from best practice, and produce guidance on implementation that address the needs of frail older people accessing EUC services. To do this, we will conduct an evidence synthesis and in-depth stakeholder interviews, analyse patient pathways and outcomes in healthcare data reflecting a range of models of care, and use the information to conduct state of the art modelling of the implications of changing pathways.

Workpackage 1 – identifying best practice (9 months)

- WP1.1 – review of reviews of EUC interventions for older people, their outcomes and costs and any implementation factors identified.(6 months, LP)
    - RQ (Research Question) 1.1.1 – what is the evidence base for EUC interventions for older people, the outcomes of these interventions and the costs associated with these interventions?
    - RQ 1.1.2 – what factors have been described in the evidence base to date that influence implementation of EUC interventions for older people?

  - Output 1.1 – a taxonomy of EUC interventions with outcome effect sizes (where available) and descriptors of costs and implementation factors.
- WP1.2 – patient and carer preferences (6 months, SC)
  - RQ 1.2.1 – what elements of care are most important to older people and their carers with EUC needs?
  - RQ 1.2.2 – how could EUC interventions be configured to best meet the needs of older people?
  - Output 1.2 – description of patient and carer priorities for EUC
- WP1.3 - staff perspectives (6 months, GM)
  - RQ 1.3.1 – what other interventions, not yet reported in the literature, offer promising models for improving outcomes for older people in the EUC pathway?
  - Output 1.3 – staff perspectives on the 'state of the art' and factors that will facilitate implementation

Workpackage 2 – qualitative study of delivery of exemplar EUC pathways (12 months, GM)

  - RQ 2.1 what aspects of interventions, context and approaches to implementation facilitate and hinder delivery of EUC interventions for older people?
  - Output 2.1 – context-, implementation- and intervention-related influences on delivery of interventions for older people in EUC settings

Workpackage 3 – routine patient level data analysis (30 months, AS)

  - RQ 3.1 Are some EUC pathways associated with better patient outcomes than others?
  - RQ 3.2 Have EUC pathways improved or got worse over time?
  - RQ 3.3 Over and above the EUC pathway, what patient characteristics, demand and supply factors explain differences in outcomes from place to place and over time?
  - RQ 3.4 What is the relationship between outcomes and the costs of the EUC pathway and are some pathways more cost-effective than others?
  - Output 3.1 – estimates of what drives better outcomes and lower costs for older people with EUC needs

Workpackage 4 - improving emergency care pathways (24 months, SB)

- WP4.1 – baseline simulation model development (12 months, SB)
  - RQ 4.1 what is the best way to build an "archetypal" or baseline model of patient flow into and out of one specific EUC pathway, ensuring that the model is valid and captures all the relevant factors?
  - Output 4.1 – a validated quantitative (stock-flow) system dynamics model of patient flow, describing the *status quo* situation in one specific setting
- WP4.2 – "what-if" analyses (12 months, SB)
  - RQ 4.2 what changes can be made to existing EUC pathways that will lead to greatest improvements, and what might the consequences of such changes be for the wider healthcare system?
  - Output 4.2 – a family of system dynamics models based on output 4.1 describing the whole-system impact of evidence based, patient centred interventions applied to EUC pathways

Research Plan / Methods

This mixed methods study will be undertaken in four inter-dependant workpackages.

Workpackage 1 (Months 1-9) – identifying best practice. Leads LP, SC, GM

WP 1.1 – review of reviews of EUC interventions for older people, their outcomes and costs and any implementation factors identified (months 1-6, LP)

We will review the evidence base on models of care in emergency and urgent care and their impact on outcomes for older people by undertaking a review of existing reviews, and developing a taxonomy of interventions based upon this review. The rationale for undertaking a review of reviews is based upon the recent, high quality reviews that have been published in this area[9, 14, 27-37] outlining models of care in Emergency Departments (EDs) and their impact on outcomes for older people.

There are four broad ED models of care that are described in the literature:

1. Classical emergency care services – predominately staffed by doctors and nurses trained in emergency medicine (without a specific focus on older people)
2. Emergency care services as above, augmented by gerontological support – mainly nurse specialists, and increasingly therapists, providing support usually 'in office hours' to EDs
3. Geriatric liaison services (nurses, therapists and geriatricians) supporting during office hours
4. Embedded geriatric services with a fixed bed base collocated within ED, and providing liaison and support – allowing a daytime presence to be supplemented by access to ambulatory geriatric beds for patients attending throughout the 24 hour cycle.

Prior to the start of the review, a full study protocol will be developed and the review of reviews will be registered with PROSPERO. The review of reviews will use standard, systematic methods.

Firstly we will undertake a literature search to identify published reviews. The search strategy will be based on those used in previous reviews (Appendix 1). Searches will be run in a range of databases, also listed in Appendix 1. The identified studies will be downloaded from databases and managed using Endnote. We will also undertake cited reference searching of included reviews and scrutinise the reference lists of included reviews to identify evidence. Where permitted by the databases, the searches will be limited to 2005 onwards, published in peer reviewed journals and written in English.

Screening and coding of reviews will be undertaken in Endnote according to predefined eligibility criteria, derived following consultation with the study team and the External Stakeholder Group. Screening of titles and abstracts will be undertaken by two reviewers and disagreements resolved by use of a third reviewer, using full text of articles if required. Reviews must include data on patient outcomes and a full list of *a priori* eligibility criteria will be included in the study protocol.

Data will be extracted from the full text of reviews into Excel by two reviewers. Data extraction will be based on a predefined list of key variables, developed by the research team with reference to the review typology development and research questions. An assessment of the methodological quality of the reviews will be undertaken alongside the data extraction using the AMSTAR checklist[38].

Data extracted from reviews will be synthesised both qualitatively and quantitatively. Where possible, effect sizes for interventions will be reported. Data on outcomes and costs of interventions will be

reported using narrative and tabular formats. Data on implementation factors will be reported narratively. Data will be combined and aggregated in order to develop the taxonomy of interventions.

Alongside reporting of the findings, we will report our findings on the internal validity of the reviews (AMSTAR[38]) and their applicability to the UK setting. We will summarise the overall evidence base, including overlap between reviews using a citation matrix, which will map primary studies to the reviews that they are included in, and will allow us to assess the size and scope of the evidence base.

We will use the review to create a taxonomy of EUC interventions, and where reported, their associated effect sizes, barriers and facilitators to implementation, and associated costs. The taxonomy will allow us to formally describe the models described in the reviews. In addition, through the staff interviews and the analyses from WP2, we will identify any additional models that may have not been published in these reviews. The taxonomy will be drafted, discussed and finalised with the support of the External Stakeholder Group. We will test the taxonomy by asking the stakeholders to classify services identified in a survey conducted across one region of the UK (Yorkshire & Humber), which represents the whole range of EDs (both large, small, urban and rural; Appendix 2) on two separate occasions, using a web-based platform, in order to check for inter-rater and test-retest reliability. It is possible that additional models will emerge during the field work, which can be added to the taxonomy in preparation for the Systems Dynamics modelling later in the programme of work.

Output 1.1 – a taxonomy of EUC interventions with effect sizes, descriptors of costs and implementation factors

WP 1.2 – patient and carer perspectives/preferences (months 4-9, SC)

In parallel with the review process, we will also interview older people and their carers where appropriate, with recent or current experience of emergency care. The aim of these interviews will be to create an understanding of what 'good looks like' from service users, helping add a strong patient and carer perspective to what we learn from the literature, which contains relatively little on patients' and/or carers' priorities and preferred outcomes. These perspectives will also be used to inform the analytical and modelling exercises detailed in WPs 3 & 4.

Participants will be recruited from hospitals in the East Midlands, to prevent 'contamination' of the sites in the Yorkshire & Humber region that might be case studies in WP2 (potential participants will need to be identified to the research team by the clinical teams – who in turn would be exposed to the study's aims, which might affect their practice). We will use a purposive recruitment strategy to ensure that recruitment reflects the population of interest, defined by the linked databases (in terms of age, frailty, cognition, ethnicity, mode of conveyance and so on), as well as recruiting from large teaching hospitals and smaller district general hospitals, to maximise generalisability. Recruitment will be undertaken by experienced research assistants or nurses, who will be very aware that many older people will have communication barriers such as dementia or stroke, meaning that a consultee consent or assent process will be required. Where possible, carers will also be interviewed, alongside or separate to the patients, according to individual preferences. The researchers will be supported by professional interpreters to ensure that older people from a range of ethnic backgrounds are included.

Potential patient/carer participants will be approached and recruited whilst in hospital during an emergency care episode, but interviews will usually take place (probably less than 30 days) after their attendance, in their own homes according to feasibility and personal choice. This approach minimises adding to any distress of being hospitalised, and allows for a period of reflection. However, we remain open to the possibility that some participants will be comfortable being interviewed in hospital. The interview schedule will be informed by the literature review (WP1.1), and developed in conjunction with the External Stakeholder Group and Patient and Public Involvement forum.

The number of participants to be recruited needs to provide theoretical saturation of the subject area (i.e. despite systematically trying to find new/contradictory insights via sampling or interviewing strategy, no new insights are gained). We anticipate undertaking around 30 interviews[39]; this may be slightly expanded or forestalled, depending on the point at which theoretical saturation is reached. Interviews will be recorded, transcribed and then analysed using the 'Framework' approach[40]. The analytic framework will be refined during the interview process and emergent themes incorporated. Data collection and analysis will be concurrent.

The output will be a description of patients' preferred outcomes in EUC, to be incorporated into the process of deciding which interventions might offer efficiencies, but also address patient preferences.

Output 1.2 – description of patient and carer priorities for emergency care

WP 1.3 - clinician interviews about emerging interventions and key elements of high quality care (months 4-9, GM)

Alongside patients and carers, the direct experience of staff of providing emergency care to older people with frailty represents an important resource on which to draw in determining what a high-quality model of care might comprise, and from which to identify promising approaches to implementing models of care put forward in the literature in real-world emergency care contexts. We will interview approximately 30 clinicians and /or managers working in EUC sampled through a national multidisciplinary reference group (n~100), about emerging interventions and key elements of high quality care. This reference group combines medicine (geriatrics, emergency care, acute medicine), as well as nursing and therapy leads with a special interest in emergency care of older people (British Geriatrics Society Frailty in Urgent Care Special Interest Group). The participants will be invited for interview either face to face or over the telephone.

Normalisation Process Theory will inform the development of the interview schedule, addressing likely challenges implicated in the process of integrating, normalising and embedding new practices. Interviews will focus on the nature of the novel interventions and approaches to care being led and delivered by participants, including the nature of the clinical and organisational problems being addressed, the rationale (theory and empirical evidence) behind the approach adopted, details about the composition of the intervention and the challenges involved in implementation, and emerging evidence for impact (including intended and unintended consequences for patients, carers, staff, the Emergency Department, the wider hospital and the wider system). Interview schedules will be informed by insights from WP1.1, and by theoretical frameworks for the study of the implementation

and normalisation of innovative approaches to providing care[41, 42]. A particular focus here will be the fit of plausible interventions with particular clinical and organisational problems, and the challenges involved in implementing them in practice in real-world EUC settings, with a view to informing the focus of the further qualitative work to be undertaken in WP2. In common with WP1.2, interviews will be digitally audio-recorded, transcribed, and then analysed using the Framework approach[40]. We will use NPT categories and terminology to inform first-order coding, alongside empirically derived codes. These will be developed through progressive focusing of codes to merge conceptually and empirically derived constructs, and provide a theoretically informed understanding of the process of incorporating 'frail friendly' activities into the work of emergency departments.

Output 1.3 – staff perspectives on the 'state of the art' and factors that will facilitate implementation

Workpackage 2 (months 13-24) – qualitative study of delivery of exemplar EUC pathways, lead GM

We have already undertaken a survey of all Emergency Departments (EDs) in Yorkshire and Humber (Y&H) that map onto our routine database (Appendix 2). Responding EDs have stated that 71% have MDT input to the ED for older people and 57% have a geriatric in-reach service. Sites that reflect the different models of care captured in the taxonomy (WP1.1), and/or which appear to exhibit extreme patterns of service delivery for older people (WP3), will be invited to participate as case studies.

We anticipate identifying 4-6 sites, which we will examine in more detail, covering how they work, and elucidating the contextual, social, cultural and organisational prerequisites for effective delivery of models of care for older people. This workpackage cannot be characterised as an ethnography in the narrowest sense of the word (as an integrative, in-depth, emic description of a community in its full complexity), but rather as deploying ethnographic (non-participant observation) methods to complement the *post-hoc* accounts of the interviews with direct observation of clinical and managerial practice as it takes place. This will account for around 20 hours of observational work in each site; the focus of our attention will depend on the approach taken to care in the case-study sites chosen, but for example where the approach takes the form of a specific model with a dedicated multidisciplinary team, we will seek to ensure that we access to the 'frontstage' and 'backstage' activities. This then will include (i) frontstage interactions with patients, day-to-day fit into wider care pathways, interactions with other clinical teams in the ED and beyond, and (ii) the backstage work of organising the team, negotiating interfaces with other clinical services, enacting relationships of accountability with managers and so on. We will also draw on documentary sources to examine this backstage work, particularly when our time in the field affords only limited opportunities to observe such meetings in practice. Issues arising from our observational work will also feed into our choice of interviews and the subjects of interviews; emergent themes from interviews will likewise feed recursively into observational work. Data including interviews, observations and collected documents will accordingly be analysed together, with a view to securing the clearest view possible of the characteristics of the exemplar EUC pathways, how they relate to their wider contexts, and how these approaches might inform models that have potential in other settings. We will rely primarily on in-depth interviews with key members of staff involved in the planning, management and delivery of these services (15-20 per

site), and will also undertake documentary analysis and ethnographic data collection. Building on the insights generated in WP1.3, interviews will focus on the composition of the interventions themselves, and the work involved in securing fit with the clinical and organisational context of the ED, wider care pathways, and the wider hospital and system environment. This will also be informed by theoretical frameworks that offer purchase on the range of practical, relational and cognitive activities involved in ensuring the fit of novel ways of working with existing practices, including Normalisation Process Theory[42]. Ethnographic observation will complement these interviews, involving up to 20 hours' of observational work per site with a focus on the day-to-day activity involved in delivering these EUC pathways, including both 'frontstage' clinical work and the 'backstage' organisational work of coordination between professionals, formal and informal meetings, and liaison with other parts of the system (e.g. referrers and ambulance teams, acute inpatient departments, and community-based teams providing ongoing support for patients post-discharge). Document collection will augment this understanding of the backstage work involved in implementing and normalising novel EUC pathways. Together, these data collection activities will permit:

1. the identification of potentially crucial and quantifiable variables to incorporate into the Systems Dynamic model (WP4) and
2. wider aspects of service delivery that are crucial to feasibility and implementation for older patients attending, including processes within the ED and cultural, contextual, structural factors within and beyond the host hospital trust.

Interviews will be audio-recorded and transcribed in full. Field notes from ethnographic observation will be recorded *in situ*, supplemented immediately following data collection through an audio-recorded account by the researcher which will subsequently be transcribed. We will then undertake a process of team-based 'debriefing' of the ethnographic researcher, whereby other members of the team will probe her/him on key aspects of her/his observations; this process will again be recorded and transcribed. We have found this approach to be highly effective in revealing further insights into the data and informing formal analysis as well as the focus of further data-collection activities.

Analysis for WP2 will use an approach based on the constant-comparison method[43], allowing for a more inductive understanding of the data produced. As with WP 1.3, we will draw on NPT, using its categories and terminology to inform first-order coding, alongside concrete, empirically derived codes. These will be developed through progressive focusing of codes to merge conceptually and empirically derived constructs, and provide a theoretically informed understanding of the process of incorporating 'frail friendly' activities into the work of emergency departments. The interviews with staff in this workpackage will also help generate information about the possible range of pathways and the 'bottlenecks' in the system that affect the older patient experience.

Output 2 – implementation factors likely to facilitate better patient outcomes and inform the System Dynamics model (WP4)

Workpackage 3 (months 1-30) –patient level data analysis to describe EUC pathways and outcomes, lead AS

We will use an existing linked database covering 2011-2017 to describe EUC pathway experienced by people aged 75+ across the Yorkshire and Humber (Y&H) region and over time (Appendix 3). The Yorkshire and Humber region is a large area of the UK representing a population of 5.4 million people. It is a mixture of large urban, smaller urban, suburban and rural settings with urgent and emergency care provided in 14 acute hospital trusts with 19 Emergency Departments (ED) (just over 10% of all English EDs). The hospitals and Emergency Departments are of mixed size from small rural hospitals to large major Trauma Centres. The unique dataset we have developed is a complete set of routine data from every acute hospital, ambulance service and NHS 111 service linked across the whole region and patient journey. In this respect we believe the system is representative of the whole country and therefore analysis of it is generalisable.

Routine patient level data has been collected from electronic data sources e.g. Ambulance Service Computer Aided Dispatch (CAD) Data and Emergency Department (ED)/inpatient Patient Administration Systems. The dataset equates to around 20 million patient episodes, of which 1.3 million are for people aged ≥75. Data has been extracted to: 1) record information about the acute episode in order to link the pre-hospital episode with subsequent hospital attendance and; 2) provide clinical characteristics of the presentation, details of the pathway of care and disposition of the patient. A proportion of ambulance service 999 and NHS 111 calls will be transported to EDs and other urgent healthcare providers. A process of data linkage of those pre-hospital emergency and acute care episodes conveyed has helped us to describe, understand and detail the full pathway of care undergone by these patients. In these instances, the ambulance service and NHS 111 data is linked with data of participating healthcare providers by using patient identifiers to make the linkage. Probabilistic matching methods were used to link the records from different providers within the system in order to build a picture of the patient journey from call to discharge from the system. The project builds on work ongoing through the Y&H CLAHRC and the Connecting Cities Project in using large datasets, and is the only database available nationally that links such information.

The database allows us to track patient journeys from the initial emergency call, through conveyancing by ambulance to the ED, and to hospital admission or transfer home. For the analysis in WP3, the basic unit of observation will be defined as the patient's journey from the initial emergency call to discharge to usual place of residence (either from the ED or hospital) or to death. The analytical objective is to assess the extent to which the pathway influences patient outcomes and costs. To perform this assessment, we need to (i) determine each patient's pathway; (ii) assess the health service costs of each patient's EUC journey; (iii) measure their outcomes; (iv) take account of factors other than the pathway that might influence outcomes and costs; and (v) jointly analyse jointly the outcomes and costs of each pathway to assess cost-effectiveness.

The typology of care models (WP1) will be applied to a recent survey describing the ED configurations in Y&H (Appendix 2), allowing patients in the database to be allocated to one or other of the various pathways. Some patients may not fit into this typology, in which case the typology will be expanded to accommodate their observed pathways. The dataset spans a number of years and many people will experience several EUC events, meaning that there will be multiple observations for each patient. Our baseline analyses of patient outcomes will account for previous EUC events, as this past history may be an important influence on outcomes. We shall also conduct longitudinal panel analyses that will take account of each patient's full history of repeated EUC events. We shall attach costs to each specific EUC event using costing data used for the purposes of calculating national productivity[44], notably the Reference Cost database.

Various outcomes are captured in the data and the patient and carer interviews (WP1.2) and PPI input will help will identify and prioritise the outcome measures to be analysed. These outcomes are likely to include: time in the ED, hospital admission, length of hospital stay (LoS), in-patient mortality*, discharge to usual place of residence or to a new institution (e.g. care home), subsequent readmission to hospital, and subsequent 111/999 calls (Appendix 3). A regression model will be constructed for costs and for each outcome measure according to its distributional characteristics (e.g. generalised linear models for costs; count or Poisson models for LoS; binary and duration models for subsequent readmissions and 111/999 calls). We shall explore the inter-relationships among outcomes, as some are likely to be correlated with others. To account for this possibility we shall analyse each outcome conditional upon preceding outcomes (e.g. initial length of stay may influence the probability of readmission[45]) and by performing simultaneous regression analyses[46].

Costs and outcomes will also be influenced by each patient's personal and medical characteristics. The linked database contains demographics and diagnostic codes, allowing us to apply risk adjustment methods to control for their influence on observed costs and outcomes. We shall account for age, gender, socio-economic status, frailty (using a recently developed frailty model that runs off Hospital Episode Statistics), diagnoses and procedures, and previous EUC events. We shall also assess measures of demand taking account of the size and composition of the local populations.

Comparatively lower costs and/or better outcomes might be achieved if the emergency care pathway were better organised. In WP 1 we shall identify various supply-side characteristics of the different pathways in Y&H. Examples of such characteristics include response and waiting times at each stage of the pathway and whether the hospital operates a 'front door' policy designed to avoid admissions. Our regression analyses will examine the influence of these on patient costs and outcomes.

In general terms, our regression model for each dependent variable (whether cost or outcomes) will take the following general form:

* We will ask NHS Digital to provide mortality flags for each patient indicating their mortality status 30-day post admission

$$Y_{iht}^{*} = \sum_{k=1}^{K} \beta_k X_{iht} + \sum_{l=1}^{L} \theta_l Z_{ht} + \sum_{m=1}^{M} \gamma_m P_{ht} + \sum_{t=1}^{T} \delta_T T_t + \sum_{n=1}^{N} \varphi_n P_{ht} T_t + \varepsilon_{iht}$$

Where Y_{iht}^{*} indicates the cost or outcome for patient *i* on pathway *h* in year *t*; X_{iht} is a vector of socio-economic, frailty, diagnosis and treatment variables measured for each patient; Z_{ht} is a vector of supply-side characteristics measured for each pathway; P_{iht} is a vector of dummy variables describing the patient's pathway; T_t is a vector of year dummies; $P_{ht}T_t$ is an interaction between the pathway and year, designed to capture changes in the pathway over time; and ε_{iht} is random error assumed to be uncorrelated with the explanatory variables.

Our primary analytical interest is in the estimates of γ_m from the outcome equations: patients on a pathway with a higher value of γ experience better outcomes, all else equal, than patients on other pathways. These estimates will be used to answer RQ 3.1 Are some EUC pathways associated with better patient outcomes than others?

The estimates of φ will capture changes in the pathways and will be used to answer RQ 3.2 Have EUC pathways improved or got worse over time? If the data suggest that over the study period any of the taxonomy pathways were introduced (or discontinued), whether gradually or suddenly, we shall seek to assess their impact using Regression Discontinuity designs.

The estimates β_k and θ_l capture respectively the influence of patient and supply-side characteristics. These will be used to answer RQ 3.3, over and above the EUC pathway, what patient characteristics, demand and supply factors explain differences in outcomes from place to place and over time?

We shall estimate the full set of cost and outcome equations simultaneously and, in order to compare their inter-relationships, we shall apply techniques designed for multidimensional performance assessment[46]. We shall explore the relationship between costs and outcomes by analysing the correlation of the γ across equations and use these estimates to compare the relative cost-effectiveness of each pathway. This will allow us to answer RQ 3.4 What is the relationship between outcomes and the costs of the EUC pathway and are some pathways more cost-effective than others?

Workpackage 4 (months 7-30) - modelling improvements to EUC pathways, lead SB

Computer simulation has been widely used for decades as a risk-free way to test out different options for service redesign in many different sectors, including healthcare. System Dynamics (SD) is the method of choice to model large complex systems[47, 48]. The aim of WP4 is to use SD to assess what changes can be made to existing care pathways that that will lead to greatest improvements, both for patients and for the wider healthcare system.

An SD model consists of stocks (accumulations) of material, and flows between them, analogous to a series of water tanks or bathtubs connected by pipes. The rate of flow along each pipe is governed by a valve that can be turned up or down. We will develop stock-flow models depicting patient flow through different EUC pathways. In our case, the "material" is patients; the stocks are the numbers of

patients in various health states (e.g. illness severity, frailty) and physical locations, and the flows are the transitions between these stocks. The models will capture the key clinical and demographic differences that influence these transitions, as well as information about the costs and outcomes associated with each EUC pathway, and will be populated with data derived from WP3.

We will first build a baseline or "as-is" model, representing the current EUC pathway in one specific Trust, incorporating findings and data from WP1-3. We next develop a family of SD models based on this model, to represent the alternative EUC pathways identified in WP1, and use these models to conduct "what-if" experiments (e.g. what would happen in Trust X if we placed a geriatrician in the ED?). Hence we shall evaluate the impact of changes to the pathway in a range of different settings.

WP 4.1 – baseline simulation model development (months 7-18)

We will develop and populate a "baseline" model for one setting, using historical data from one year, and validate it against actual data in a different year. Information from WPs 1 and 2 will feed in to the development of the patient flow model in WP4, partly quantitatively (output 1.1) and partly qualitatively (outputs 1.2 and 2.1). Output 1.1 will inform the model design: what is the current pathway, what interventions are currently offered (and to whom), and what pathways do various categories of patient follow through the model as a result? Outputs 1.2 and 1.3 will inform model outputs, although only in an indicative sense. Precise measurement of patient/carer satisfaction, for example, is not feasible, but it will be possible to incorporate patients' preferences for particular aspects of a service into the model, and this will be used to compare the relative quality of different options, in addition to numerical outputs. For clarity, constructs such as patient satisfaction that are qualitative in reality, will still be quantified in the model, i.e. measured in some hypothetical units, and equations will be developed that describe how the current values of other variables in the model determine the level of patient satisfaction. We anticipate that these equations may be generated by recognised statistical techniques such as multiple regression (in WP3). However, if key data are missing then it will still be possible to create equations empirically, or even represent the relationships graphically, based on domain expert opinion. In such a scenario, the resulting causal relationships will be tested for "face validity" with stakeholders to ensure they are plausible. The model design will be sufficiently high-level so that it can readily be applied to a number of different settings. For some stocks, we will be able to attach costs per day, or workload requirement.

Patients will enter the model via the following sources: GP referral, 111 call, 999/ambulance service, and possibly others identified from the data in WP3. Following admission to the ED, according to the chosen EUC pathway they will move through different stages (stocks) in the hospital such as the ED, short-stay unit, general medical ward, specialist geriatric ward etc, to be determined from WP1&2. Patients will leave the hospital either through death or by discharge to a *community stock*, for example home, residential care/nursing home, or step-down care. The ability to use the East Midlands AHSN algorithm to distinguish in our data between those patients who are discharged to care homes, as opposed to their own homes, will make this model unique and particularly relevant.

The model does not follow individual patients, but will include flows back from the community stocks back into the urgent care system based on data from WP3. SD is the ideal methodology to capture these feedback effects and hence the knock-on consequences of EUC interventions in the ED for the whole system, which can often be unanticipated and counterintuitive. The anticipated time horizon for running the model is three years: this is long enough to capture the system effects without making unrealistic assumptions that there will be no major organisational change in this period.

Output 4.1 – baseline stock flow Systems Dynamics model for older people with EUC needs

WP 4.2 – "what-if" analyses (months 19-30)

We will develop a family of SD models based on the original model in WP4.1, to represent the alternative EUC pathways identified in the taxonomy (Output 1.1). Some pathways may require structural change to the baseline model, i.e. the addition or removal of certain stocks and flows, whereas others may simply require changes to the model parameters, i.e. different transition probabilities or flow rates between stocks. Factors found to have the most significant impact on cost and/or outcome will be identified in WP3, and the model will then use these to classify patients. Throughout the study we will be involving stakeholders, including in the modelling process; the External Stakeholder Group will be drawn from the (currently) 95 members of the Urgent Care Special Interest Group run conjointly by the British Geriatrics Society, Royal College of Emergency Medicine and the Society for Acute Medicine. Outputs 1.3 and 2.1 (information about the factors that influence the delivery of various interventions and facilitate implementation), will provide inputs to the model for the purposes of experimentation. In Vensim, these will if possible be included as "slider bars" that the user can adjust to see the effect of increasing or decreasing a given factor. Again, these influences may be qualitative in nature and will need to be quantified in the same way as above. They will, however, show the relative impact of each factor and again, would enable users to compare options.

The model outputs, which will enable comparison between different EUC pathways, will include:

- The number of patients in each stock over time
- Total numbers of patients admitted and discharged over any period, aggregated or broken down by patient category
- Mortality, total or cumulative, aggregated or broken down by patient category
- Total costs over time for those stocks where it is possible to associate a cost per unit time.

The aim is that service planners will be able to select the model corresponding to the care pathway they want to test, and customise it with their own data. SD software allows the detailed model structure to be hidden so that all the user can see is a "flight simulator" interface where data can be read in (e.g. from a spreadsheet), simulations run and results displayed, without the need for any expertise in SD modelling.

Output 4.2 – a series of validated simulation models describing the whole system impact of evidence based, patient centred interventions applied in the ED.

Dissemination and projected outputs

External Steering Group

We will involve an existing, established national stakeholder group focussing on urgent care of older people with frailty, which we will co-opt to form our External Steering Group. This group includes:

- Leads from the NHS Emergency Care Improvement Programme, Acute Frailty Network and NHS England
- Representation from the Royal College of Emergency Medicine, British Geriatrics Society, Royal College of Physicians and the Society for Acute Medicine
- National patient/public representation
- Chartered Society of Physiotherapy & College of Occupational Therapists
- Royal College of Nursing
- Association of Directors of Adult Social Services

We have also developed links with bodies such as the NHS benchmarking agency, and policy think tanks including The Nuffield Trust and Health Foundation. We will also consult with the East Midlands Centre for Black and Minority Ethnic Health. These stakeholders will be asked to give regular input to the project, helping form and shape the research as well as being informed of emerging findings. We are also compiling a list of likely stakeholders who will need to be kept informed of the work, such as the AHSNs, Royal Colleges and NHS Confederation – others will be added using snowballing techniques to maximise breadth, as well as depth, of coverage. We have support from NHS England for this evaluation and a commitment to disseminate the findings.

We will also disseminate our findings nationally and internationally:

- Following WP1&2 we will produce a short interim document detailing a classification of the different models of service delivery, identifying what impact the different service configurations has on patient care and outcomes.
- Evidence briefings which highlight key findings and applicability of the research will be produced and distributed to key stakeholders
- Scientific papers derived from this project will be submitted to high profile journals
- Presentations at national and international relevant conferences
- We will publicise key outputs by issuing press releases, media interviews, and social media
- National dissemination events as described above will ensure that all key findings will be communicated to a specially invited audience of key individuals who are involved in the provision, use and commissioning of EUC services.

The outputs will be a detailed and rigorous description and analysis of the clinical and cost effectiveness of different models of Emergency and Urgent Care focussing on older people, along with recommendations about which models (if any) have the most impact.

Expected Output of Research / Impact

The primary output will be for service planners - NHS commissioners, managers and professionals planning or operating Emergency and Urgent Care services. We will provide a user-friendly version of our simulation model(s) within the Vensim modelling software. There is likely to be more than one SD model, depending on the nature of the pathway: some pathways may require structural change in the

baseline model, whereas others may just need different parameters. This will have a "flight simulator" interface allowing users with no modelling expertise to enter their own data and conduct their own experiments to examine the possible benefits and implications of making changes to render their services more frail-friendly.

We will provide outputs relevant to teams delivering emergency services to older people, those planning new service developments and to academics. These outputs will be designed to ensure that our research has meaningful impact for services and for older people. For all groups we will produce a user-friendly classification of the different types of care pathway which are applicable to older people accessing EUC. We will provide information on the strengths and weakness of these pathways and service models in relation to the ways in which they are 'frail friendly'. We will involve our external steering group in writing our outputs. We will undertake to hold a dissemination event to present our findings and also to use social media and press releases to disseminate our findings. For service providers we will produce briefing documents summarising the strengths and limitations of different approaches and key points of information about optimising their delivery. These briefing documents will draw on the entirety of the work in this project including evidence synthesis, stakeholder input, data analysis and modelling. We will disseminate these through communities of practice national societies and bodies of expertise represented on the External Steering Group and others as advised by these experts. Our academic outputs will include a detailed project report for the Health Services & Delivery Research journal and other high quality peer-reviewed publications and conference presentations, both nationally and internationally. We regard the impact on services of this work as of equal importance to the academic outputs and will monitor the link between the two.

Project management

The key vehicle for synthesising the various elements of this project will be through the Executive Management Team, where all workpackage leads will be present and share emerging findings and discuss implications for each workpackage. The Executive Management Team (EMT) will comprise the workpackage leads and other co-applicants. A 'Contingent Design' (as opposed to a more 'integrated design'[49]) will be employed to bring together qualitative and quantitative findings. The EMT to achieve operational objectives: they will meet at least monthly throughout the project, either face to face or by teleconference to discuss key issues of concern in the conduct and development of the research. The Gantt chart indicates the key 'transition points' (arrows) at which essential information from one workpackage will be required to inform the development of another workpackage. Table 1 summarises the roles of the co-applicants (page 19). An experienced project management team will be tasked with delivering the project on-time and on-budget. Each workpackage will form its own management structure to oversee its day to day operational conduct: they will report to the executive monthly but most activity will be managed through communication between the workpackage lead and project management team between meetings. The project management team will be supported by an administrator. A steering committee will meet approximately annually and oversee the entire project, advising on quality assurance, ethical conduct, data and project management.

'Go/no go' decision points

Although we have not described stop-go criteria as such, we have prepared a risk management section, summarised below, as well as identified key outputs on the Gantt chart, upon which subsequent work is dependant (the linking arrows).

Risk	Impact	Likelihood	Mitigation
Unable to recruit staff	High	Low	Staff named on the bid are already working at the respective institutions and have already engaged with this project.
Unable to convene External Stakeholder Group (ESG)	Moderate	Low	The ESG already exists, and is 'owned' by the British Geriatrics Society, with whom we have excellent relations. Other avenues are open to gain stakeholder perspectives. The Urgent Care Special Interest Group is now well-established, with the first conference being held in May 2018 (in part to feedback research outputs from another HSDR project to clinical teams).
Unable to engage sufficient PPI input	High	Low	Two applicants named; the Leicester PPI group is well-established and the ethnic research group already engaged. Both have re-confirmed their commitment to the project; furthermore there are additional members of the Leicester and Sheffield PPI forums that can support this project if necessary.
Insufficient literature to inform taxonomy (WP 1.1)	High	Low	We are familiar with the literature to date and can already start to describe some form of taxonomy (detailed in the bid).
Inability to recruit patients/cares (WP 1.2)	High	Low	We will work with local service where we have good relationships; we will work with the CRN to aid recruitment.
Inability to recruit staff (WP 1.3)	High	Moderate	We have requested funding to facilitate the release of staff time. This however remains a significant risk as described, as EDs are under significant pressure at the moment.
Sites decline to act as case studies (WP 2)	High	Moderate	Although services are under pressure and it is possible that those that we most want to study may decline; however they have already engaged through data sharing

			and the survey, and there are at least 14 sites from which to sample 4-6.
Unable to access linked data (WP 3)	High	Low	The datasets have already been linked, and the ethical and governance approvals granted for related projects.
Unable to 'fit' data to the SD model (WP 4)	High	Low	Brailsford is experienced at SD modelling, has already reviewed the Y&H data and is confident that if accessible an SD model can be created.

Approval by ethics committees

Ethical approvals will be required for workpackages 1.2, 1.3 & 2, with the governance applications process starting ahead of the funding being released, should the project be supported. The team are experienced in obtaining permissions for studies in older people, including recruiting patients without capacity. For WP3, the data is available and there are existing governance arrangements in place, under the auspices of the Yorkshire & Humber CLAHRC; we will seek approval to extend these to allow the anonymised data to be accessed and analysed in WP3&4. The IRAS reference for the dataset analysis is 215818, REC reference 17/YH/0024 and the CAG approval reference is 17/CAG/0024. We have allowed time in the project plan to prepare and obtain the necessary additional approvals ethics and research governance approvals.

Patient and Public Involvement

We have had a further discussion with Riley and Lalseta, who are the PPI co-applicants on this bid, to specify how they feel they can best contribute to the research project. Both agreed that monthly attendance at the Executive Management Team meetings would be too onerous and possibly not very informative, as much of the discussion in these meeting is likely to be on detailed operational aspects of the research. Rather they would prefer to attend on a quarterly basis, asking the research team to provide a specific general update on the overall progress of the project. In addition Riley and Lalseta would like to spend dedicated time with each of the workpackage leads at key points in the research to provide specific and detailed feedback, including for example:

- Developing recruitment strategies, interview schedules and contributing ideas on improving the interventions
- Attending training to allow active and meaningful participation in in the study
- Providing feedback on reports and supporting dissemination to professional groups and particularly to lay audiences
- It was decided that the involvement of lay members as co-researchers would NOT be appropriate in this study, as the context (emergency care) and the sensitive nature of the conversations, often involving vulnerable older people with communication barriers, requires skilled professional researchers, well-used to working in hospital settings

In addition, Riley and Lalseta will act as the lay leadership on behalf of the Leicester PPI forum. Both have worked together in the Leicester PPI forum for several years, and will be well supported from an

administrative perspective, with meetings and study activities planned well in advance. The PPI forum members will meet approximately quarterly, in a parallel meeting to the research team, but the chair and/or nominated deputy of the emergency care PPI forum will attend the EMT and ESG meetings to feed-in lay perspectives and findings, as well as having more flexible interactions with each of the workstreams as described above.

Finally in our more recent discussions with our PPI members, the need to examine proactive care and how that impacts upon the emergency care episode (for example, capturing this is the service descriptions, patient, care or staff interviews and triangulating with the dataset in WP3) was and will be incorporated into the proposed study.

Plan of investigation and timetable

The plan of investigation is summarised in the project Gantt chart (Figure 1), which also indicates some of the inter-dependencies of the project. We have also summarised the key outputs and proposed reporting deadlines in the online application form.

Figure 1 Emergency care for older people project Gantt chart

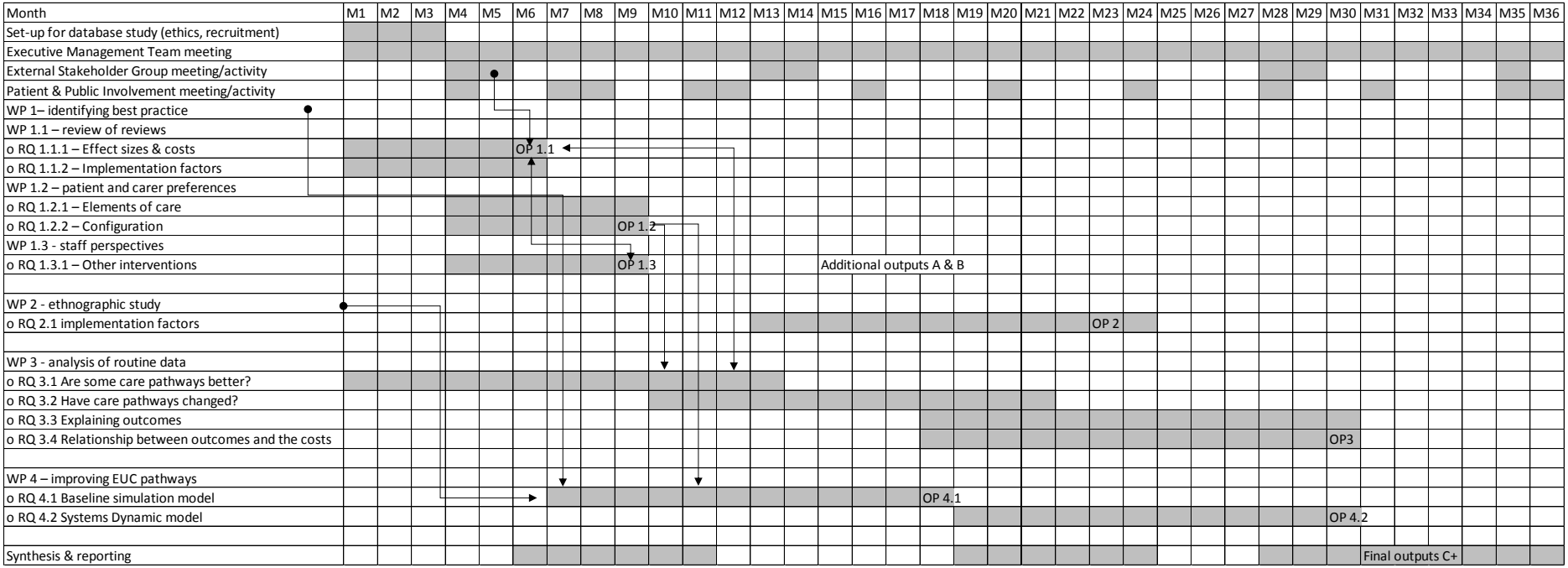

Table 1 Involvement of applicants in each of the different workstreams

	WP1 – identifying best practice			*WP2 – ethnographic study*	*WP3 – analysis of routine data*	*WP4 improving EUC pathways*	
	WP1.1 – review of reviews	WP1.2 – patient and carer preferences	WP1.3 - staff perspectives			WP4.1 – baseline simulation model development	WP4.2 – "what-if" analyses
Conroy	Methodology & clinical advice	**Lead**	Methodology including recruitment & clinical advice	Methodology including recruitment & clinical advice			
Mason	Methodological advice	Methodology including recruitment & clinical advice	Methodology including recruitment & clinical advice	Methodology including recruitment & clinical advice	Methodological advice	Methodological advice	Methodological advice
Brailsford					Methodological advice	**Lead**	**Lead**
Burton	Methodological advice	Clinical advice	Clinical advice	Clinical advice	Methodological advice	Methodological advice	Methodological advice
Martin		Methodological advice	**Lead**	**Lead**			
Maynou-Pujolràs					Methodological advice	Delivery	Delivery
Preston	**Lead**						
Street	Methodological advice				**Lead**	Methodological advice	Methodological advice
Bardsley (advisor)	Methodological advice				Methodological advice	Methodological advice	Methodological advice

Expertise and justification of support required

- Conroy (20% FTE) leads nationally on improving urgent care for older people, for example through the Acute Frailty Network.
- Mason (5% FTE) is part of the Sheffield Centre for Urgent and Emergency Care Research (CURE). Research interests include evaluating complex interventions.
- Brailsford (10% FTE) has over 25 years' experience in healthcare-related Operational Research and is one of the UK's leading researchers in this area.
- Burton (5% FTE) is an academic GP with ScHARR, whose work includes understanding complex interventions.
- Martin (10% FTE) is Professor of Health Organisation and Policy in Leicester, with long experience of leading and conducting qualitative and mixed-method evaluations.
- Maynou-Pujolràs (20% FTE) is an Applied Health Economist at the LSE, focussing upon Economics and Health Inequalities, Health Technology Assessment Public Policy Evaluation.
- Preston (WP1 80% FTE, then 5% FTE) is a Research Fellow and Information Specialist in the Information Resources Group at ScHARR.
- Street (5% FTE) is a Professor of Health Economics at the Department of Health Policy at LSE, and formerly Director of the Economics of Social and Health Care Research Unit, York.
- Bardsley (advisor) is an experienced health service researcher with roles at The Health Foundation and the Nuffield Trust.

In response to earlier feedback, we have co-opted the following special advisors to the project: Tamsin Hooton, Director of Urgent Care, Leicester, Leicestershire and Rutland CCGs; Martin Vernon and Jonathan Benger National Clinical Directors for Older People and Urgent Care, NHS England.

The total study cost is £907,261, around £36,000 less than the original submission, as we have reduced the administrative support to the study. There were concerns about project management costs, which we suspect relate to our plans to work with two experienced qualitative researchers in Leicester who will be undertaking project management roles, as well as a significant amount of field work in years 1-2, focusing upon dissemination activities, publications and reporting in year 3. As requested we have summarised the approximate costs per workpackage below:

- WP 1– identifying best practice:
    - WP 1.1 – review of reviews and synthesis, Sheffield ~£100,000
    - WP 1.2 & 1.3 – ~30 patient/carer interviews and ~staff interviews, analysis and reporting, as well as project management, Leicester ~year 1 costs at £75,000
- WP 2 - ethnographic study in 4-6 sites, up to 80 staff interviews documentary analysis and repotting as well as project management costs, Leicester ~year 2 costs at £75,000
- WP 3 - analysis of routine data: this approximates to LSE staff costs ~£50,000
- WP 4 – improving EUC pathways: this approximates to Southampton costs ~£60,000
- Other costs such as PPI, external stakeholder group meetings, executive management meetings throughout the project, and costs to cover staff time (reviewed by the East Midlands CRN) and transcription in WP2 amount to £70,000
- These directly incurred costs amount to approximately £430,000, to which we need to include the co-applicants and overheads from the HEIs.

Uploaded documents: Appendix 1 search strategy, Appendix 2 – Y&H survey, Appendix 3 – database fields, Appendix 4 – EMASHN care home algorithm, Appendix 5 – Letter of support from East Midlands CRN, Gantt chart and references.

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