Exploring the economic case for investing in advanced practice nurse training: an innovative nursing role to support the delivery of specialist coordinated neuro-rehabilitation services for young adults following a stroke

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DISCLAIMER

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1. INTRODUCTION

The number of stroke cases has reached more than two million in UK (with more than 100,000 strokes each year). A recent report in the Lancet (Ekker MS et al, 2018) suggests that the incidence of ischemic stroke in young adults (18–50 years) has increased. These patients generally have long life expectancy after stroke, and the costs of their long-term care can generate challenges for health and social care systems. The complex nature of the condition and the special needs of the younger adult population (living with the consequences of stroke for longer, with potentially considerable impacts on their ability to continue learning and education, as well as their ability to return to work or being a parent) means that professionals with specific expertise and training are needed to help diagnose and manage them in acute settings and for the longer term in the community. In addition to providing expert knowledge on conditions and treatment options, specialist care should incorporate tailored care planning, integration of care and multidisciplinary working. Specialist coordinated rehabilitation services in the UK have been developed to meet the needs of young adults. They differ from services for 'older adults', which may be justified by the fact that younger individuals often have different goals for rehabilitation (such as returning to work or being a parent) that may be less relevant for an older population. In addition, younger adults may have greater expectations about continuing learning and adapting over the longer term. Since both the individuals who have had a stroke and their families may face living with the consequences of disability for many years, it would obviously be of benefit if individuals could achieve greater independence, for example potentially through longer, more intensive and more skilled rehabilitation support).

This project explored the economic benefits of closing treatment gaps in the provision of rehabilitation through development of a programme to train Advanced Practice Nurses – APNs – in appropriate neuro-rehabilitation care (with APNs as part of multidisciplinary teams).

2. METHODS

The economic argument was built up from the anticipated better outcomes for patients in terms of cognitive, behavioral and psychosocial gains, better overall health, improved quality of life, improved employment and educational impacts and other impacts.

We looked at the effect of training registered nurses for the role of APNs (as part of a multidisciplinary team) on the rehabilitation care for young adults with stroke when possible (although some evidence was also used for (all) adults with stroke).

Based on a preliminary review of the literature and with the support of experts, we identified different interventions delivered by a multidisciplinary care team that would involve a contribution from nurses with an advanced practice role. In doing so, we considered three (overlapping) areas of the stroke care pathway (see Figure 1):

- Acute care/ in-patient rehabilitation;
- Early supported discharge (to community);
- Discharge to specialised rehabilitation centres.

For each area of the care pathways we examined the change in outcomes compared with current care. Following that we looked at whether the effects in terms of those outcomes appear to represent good value for money. Where possible different consequences were considered to include:

- Costs to the NHS associated with poor physical or mental health;
- Costs to social care (e.g. personal care, aids and adaptations);
- Economic effects of exclusion from or reduced opportunities within the labour market (reduced personal income, lower national productivity, social security benefits);
- Economic impacts on other family members (disrupted employment, impact on income, out-of-pocket payments);
- Costs of unpaid care time;

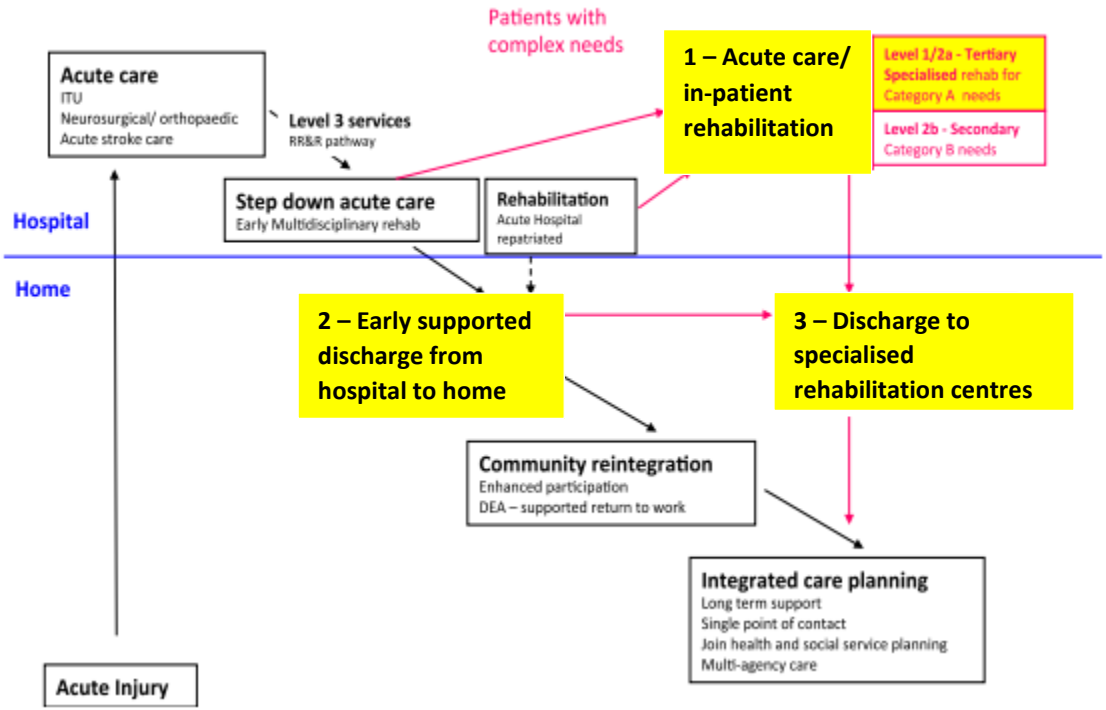
- Value of wellbeing losses from premature death, reduced quality of life.

Following that, we produced new calculations of the additional NHS costs that would need to be invested to deliver the rehabilitation services (three overarching areas of the stroke care pathway).

The economic benefits associated with these gains were estimated by comparison to current provision and current experiences for people who have had a stroke. We also reported the cost of delivering the training programme and delivery of the interventions from the ANP workforce. These costs were included in the proposed outputs. In doing so we looked at the care pathway for patients with sudden onset injury (including stroke).

By 'economic case' we mean whether an intervention is cost-effective and affordable, paying particular attention to a range of costs and outcomes (across budgets, sectors) and over different time periods. We sought to identify direct (immediate or longer-term) savings to various public budgets, to other stakeholders (e.g. young adults with stroke using services, their families or their employers) and cost-effectiveness gains where there are no savings as such but the additional costs are seen by decision-makers to be justified by a gain in outcomes.

Figure 1: Care pathway for patients with sudden onset injury (including stroke)



Note: Adapted from NHS Commissioning Board (2013). NHS standard contract for specialised rehabilitation for patients with highly complex needs (all ages). Rehabilitation services are planned and provided in coordinated regional networks over a relatively small geographical area. Local general (level 3) rehabilitation services provide for the majority of patients, but a smaller number are referred to specialist (level 1 or 2) services, which take a selected population of mainly younger adults with complex needs for rehabilitation that are beyond the scope of their local rehabilitation services (British Society of Rehabilitation Medicine, 2015). The five types of interventions presented in this report are in yellow.

2.1 BENEFITS OF REHABILITATION SERVICES (WITH APN WORKING AS PART OF THE MULTIDISCIPLINARY CARE TEAM)

Data were extracted from a range of sources, including evidence sourced from Cochrane library (for examples see: Langhorne et al, 2017, Turner-Stokes et al 2016), NICE guideline (2013), published evidence from Pubmed, Medline and Embase as well as research recently completed at Care Policy and Evaluation Centre (CPEC, formerly PSSRU) on current, future and avoidable costs of stroke in the UK (led by Anita Patel in collaboration with CPEC; Patel et al, 2017). We included also CPEC papers looking at projections of demand for and costs of social care for older people and younger adults in England, 2015 to 2035/40 (including younger people affected by stroke; Wittenberg et al 2015 ad 2018).

In addition, the National Clinical Audit for Specialist Rehabilitation following major Injury (NCASRI; https://www.hqip.org.uk) had looked at the scope, provision, quality and efficiency of specialist rehabilitation services across England and improve the quality of care for adults with complex rehabilitation needs following major trauma. A key component of NCASRI was to link data from the Trauma Audit Research Network (TARN) and the UK Rehabilitation Outcomes Collaborative (UKROC) datasets through the NHS number, in order to track patients along their journey from the Major Trauma Centres to the specialist rehabilitation services and to examine the outcomes and cost efficiency of rehabilitation for patients with major trauma. Relevant publications were searched to identify economic data on specialist care delivery (including APN) in the UK (for example see: Turner-Stokes L, et al (2016), Singh R et al, 2017).

We also searched the database of evidence published by the Clinical British Society of Rehabilitation Medicines Evidence (https://www.bsrm.org.uk/), the Neurological Alliance (https://www.neural.org.uk/) and other sources.

As the purpose of this report was to illustrate the evidence that already exists and potential gains from implementation (rather than to conduct a thorough review of evidence of APN-based stroke interventions), these reviews were pragmatic rather than systematic. They focused on identifying interventions with evidence of potential

economic gains, as well as evidence of effectiveness. When possible, we reported evidence from systematic reviews rather than from individual studies, and we extracted information that would enable us to showcase or estimate potential economic outcomes. The methodological approaches varied across each intervention, according to the nature and strength of evidence. The focus of the research was on young adults with application to the UK, but we considered using evidence from other settings, in Europe and overseas (such as the USA and Australia) when applicable to the UK. Discrimination between young adults and adults were made when data were available. Data were extracted from publications dated 2003 onwards. A narrative synthesis was undertaken to summarize and report the findings. Details on the individual studies summarized in the report are presented in separate appendices.

2.2 NEW CALCULATIONS: MONEY THAT WOULD NEED TO BE INVESTED BY THE NHS TO DELIVER REHABILITATION SERVICES (WITH APN WORKING AS PART OF THE MULTIDISCIPLINARY CARE TEAM)

Table 1 summarises the unit costs for training and delivery of the interventions. The training needed to prepare registered nurses for the role of APNs would include being educated to Master level (MSc advanced practice, general) followed by a bolt on specialism module (see RCN standards for advanced levels of nursing practice, personal communication from experts). English national estimates for the MSc course fees were based on published data for the academic year 2019/20. Data on the bolt on module (duration: from 16 weeks to 6 months; University fees: average £1,800) were provided by experts. The training costs per APN were around £16,000 (average training duration: 3.5 years for completing both MSc and bolt on module). Annual salary figures for an APN varied between £44,606 to £50,819 (NHS salary band 8a; www.nhsemployers.org).

NHS funding invested to deliver advanced practice nurse-based interventions (as part of the multidisciplinary team) may vary according to employee experience. We described different scenarios, where we varied the years of experience of the APN staff. For each scenario we considered NHS investment costs for different delivery periods (one, two and 5 years). In our calculations we assumed that the postgraduate

training fees and the salary costs that would need to be invested to deliver the APN-based rehabilitation services were comparable across the three overarching areas of the stroke care pathway considered above (i.e. emergency/acute care services, early supported discharge to community, and discharge to specialised rehabilitation centres). An annual discount rate of 3.5% was used for duration greater than one year.

Table 1: Unit costs for training and delivery of the interventions in England

POST GRADUATE TRAINING (2019 VALUES)	
MSc course (advanced practice nurse)*	Duration: average 3 years (min 2 up to 6 years)
	Total fees: average £14,000 (min £6,000; max £55,500)*
Bolt on module (to enhance existing specialism skills at an advanced level)**	Duration: from 16 weeks to 6 months Total fees: average £1,800 (min £700; max £2,800)
Overall training costs per advanced practice nurse (MSc + bolt on module)	**Total fees: ~£16,000**
DELIVERY OF THE INTERVENTION (ANNUAL STAFF COSTS PER ADVANCED PRACTICE NURSE, 2019 VALUES)* **	
SCENARIO 1: < 1 year of experience	£44,606
SCENARIO 2: 1 - 2 years of experience	£44,606
SCENARIO 3: 2 - 3 years of experience	£44,606
SCENARIO 4: 3 - 4 years of experience	£46,331
SCENARIO 5: 4 - 5 years of experience	£48,324
SCENARIO 6: 5+ years of experience	£50,819

*Estimates are based on data published by a convenient sample of 15 English universities offering an MSc course in nursing advanced practice (academic year 2019/20). ** Personal communication from experts. ***NHS pay scale Band 8a, excluding London allowance (www.nhsemployers.org).

3. BENEFITS OF REHABILITATION SERVICES (WITH APN WORKING AS PART OF THE MULTIDISCIPLINARY CARE TEAM)

3.1 EMERGENCY/ACUTE CARE SERVICES

Sources of evidence: a systematic review of randomised controlled trials (RCTs), quasi-experimental studies, prospective and retrospective cohort studies of the

impact of the advanced practice nursing role on quality of care, clinical outcomes, patient satisfaction, and cost in the emergency and critical care settings (Woo et al; 2017). It included a total of 15 studies, presented in details in appendix 1. We also sourced data from on a prospective cohort study published by Turner-Stokes L, et al (2016), looking to evaluate functional outcomes, care needs and cost-efficiency of specialist rehabilitation across multicentre provision of acute services with complex neurological disability - including stroke.

Patients: at least 16 years of age, requiring acute care.

Settings: Emergency departments (EDs), trauma centers, intensive care unit (ICU), or high dependency units.

Interventions: advanced practice nurse (APN)-/ nurse practitioner (NP)-directed emergency or critical care inpatient rehabilitation services (compared with those of the physician-directed care. We also included studies with interventions which compared the physician-only model of care with APN-physician or NP-physician collaborative model of care. They all included contribution from registered nurses in advanced practice role.

- **Nurses:** registered nurses in advanced practice role, i.e., named as either APNs or NPs according to different country settings (Pulcini J et al 2010). Nevertheless, with either NPs or APNs (NP/APNs) we intended registered nurses "who acquired the expert knowledge base, complex decision-making skills and clinical competencies for expanded practice" (Gordon CR et al, 2006, p. 26) and enter the workforce with a master's degree (Schober M, et al 2006).
- **Doctors/Physicians**: emergency doctors/physicians, intensivists, residents, medical officers, hospitalists, or house officers in the emergency department (ED) or intensive care Unit (ICU) or high dependency units.

Evidence on effectiveness of interventions:

- **Emergency setting, length of stay**. Patients who were reviewed and treated by NP/APNs reported a significant reduction in the length of stay in EDs when compared to those seen by physicians (Jennings N, et al 2008; Colligan M, et al 2011). However, the shorter time was attributed to the baseline difference in patients' severity between the groups. In particular, a study considering groups of similar baseline patient acuity for both NPs and physicians found comparable lengths of stay in EDs when patients with chest pain were managed by either NPs or physicians (Roche et al 2017). Similar length of stay in ED was also reported when patients were managed adopting either a NP-physician collaborative model of care or usual physician-only model of care (Steiner IP et al 2009).
- **Emergency setting, waiting time to consultation**. The majority of papers comparing NP-directed care with physician-only care found similar waiting time to consultation in EDs (Steiner IP, et al 2009; Jennings N, et al 2008; Dinh M, et al 2012). Only Colligan M, et al 2011 reported that patients with minor injuries experienced shorter waiting time (median 14 min) when reviewed by emergency NPs than those reviewed by physicians (median 50 min).
- **Emergency setting, waiting time to treatment.** One RCT (Jennings N, et al 2015) reported that a greater proportion of patients (15.4%) managed by emergency NPs received analgesia within 30 min of arrival at the ED compared to patients managed by physicians (1.6%) ($P < 0.01$).
- **Emergency setting, patient satisfaction**. Of the 15 studies examined by Woo et al (2017), two examined patient satisfaction in the emergency setting. Roche TE et al (2017) found similar patient satisfaction scores when comparing NP-directed care with physician-only care while Dinh M, et al (2012) reported NPs to receive higher patient satisfaction scores than physicians
- **Critical care setting, mortality**. Five (Skinner H, et al 2015; Hoffman LA, et al 2006; Landsperger JS, et al 2015; Moran JL, et al 2016; Scherzer R, et al 2016) out of the 15 studies analyzed by Woo et al (2017), the impact of the advanced nursing practice roles (either NP-directed care or NP-collaborative care vs. physician care only) on hospital and ICU mortality. All studies found comparable hospital mortality between the two groups of patients (receiving care from advanced

nursing practice roles vs. physician only). Landsperger JS, et al (2016) suggested that NP-directed care had the same quality as physician-only care. The patients under NP-directed care had statistically significant lower ICU mortality (6.3%) than those under physician-only care (11.6%; $P < 0.01$).

- **Critical care setting, length of stay**. Morris DS, et al (2012) and Goldie CL, et a (2012) found comparable lengths of stay in hospital between the comparison groups (NP-directed care versus physician-only care), whereas a large cohort study (Landsperger JS, et al 2008) reported a significantly shorter length of stay in medical ICUs for patients whose management were led by NPs than those under physician-only management. However, we need to be cautious in inferring greater efficiency in NP-directed care as presented in the latter study, as the comparison groups presented differences in the patients' characteristics. All studies (David D, et al 2015; Hiza EA, et al 2015; Hoffman LA, et al 2006; Scherzer R, et al 2016) that compared NP-based collaborative model of care with usual physician-only model of care found similar lengths of hospital stay between the comparison groups. When looking at the subgroup of patients in greater need of communication with multidisciplinary teams, discharge planning, care coordination, and demanding more administrative work, the patients managed according to NPs-physician collaborative model performed better than the comparator (physician-only care; Hiza EA, et al 2015).
- **Critical care setting, waiting time to treatment**. Advanced nursing practice role (including 24/7, on-site coverage with an acute care NP as first responders for acute ischemic stroke) significantly reduced the time to treatment (median 45 min) in comparison to the usual service model (median 53 min) ($P < 0.01$).
- **Critical care setting, patient satisfaction**. Only one study (Goldie CL, et al 2012) examined patient satisfaction in the critical care settings. They found that NPs performed better than physicians in teaching, answering questions, listening, and pain management.

Evidence on cost-effectiveness of interventions:

- **Critical care setting, hospital charges (USA).** When comparing NP-physician collaborative care with physician-only care in the critical care setting Scherzer R et al (2017) found that, despite the longer ICU length of stay in the group of patients receiving NP-physician collaborative care, overall hospital charges did not differ significantly compared with the other group receiving physician-only care, suggesting that use of resources remained similar between the two populations. This finding supports previously published work that NPs are cost-effective providers (Burns SM, et al. 2003; Gershengorn HB, et al 2011).
- **Critical care setting, staff costs (UK).** Skinner et al (2013) assessed the feasibility and safety of NPs continuing first-line care on a cardiac ICU with junior doctors becoming non-resident when on-call. The junior doctors resident on the cardiac ICU were supported by seven NPs. The junior doctors' rota was supported by non-resident consultant doctors. At the time of the change the cardiac ICU had nine level three and six level two beds and an annual throughput of approximately 700 patients after cardiac surgery. The hospital board wanted to be reassured that NPs possessed the knowledge, skills and attitudes to provide safe rehabilitation care on the cardiac ICU, including also dealing with emergency cases of cardiac arrests. The study showed that training opportunities for junior doctors increased and costs were reduced. The annual cost of staffing the junior doctor and NP programme before the change was £933,344 and £764,691 (2010 prices) afterwards.
- **Critical care setting, hospital stay costs (USA).** Hiza E et al (2015) assessed whether hiring a NP could be beneficial in diminishing length of stay (LOS) and thus decrease annual hospital costs for the trauma center. The trauma center hired a single NP to join the orthopaedic trauma team. Proposed duties of the NP included assisting the orthopaedic intern with daily floor work such as arrangement of social service needs, discharge planning, and paperwork. The subsequent goal of adding a NP included improved communication between the orthopaedic trauma team and their patients, as well as their ability to act like a liaison for the orthopaedic trauma team in daily multidisciplinary meetings between the physical therapists, nurse case managers, social workers, and other

physicians. Analysis of all patients discharged from the orthopaedic trauma team (one year before adding the NP to the orthopaedic trauma team vs. one year afterwards revealed an overall decrease in the mean LOS from 6.02 days in the pre-NP group to 4.91 days in the post-NP group (statistically non-significant results). Breaking down patients into subgroups by age showed that in the subgroups of patients younger than 60 years, LOS was decreased by 1.03 days (from 5.79 to 4.75 days, statistically non-significant results). When looking at the subgroup of patients who were transferred from the trauma service to the orthopaedic service and subsequently discharged from the orthopaedic service the LOS was decreased by 6.54 days (from 13.56 to 7.02 days, $P<0.01$). Cost data were derived looking at the average cost of a 24-hour period stay at the level I trauma center. On average, a cost of $2000 per 24 hours is incurred (USA, 2012 prices). A cost analysis of each subgroup of patients that showed a statistically significant decrease in LOS was performed. For example, among the subgroup of patients discharged to rehabilitation facility, the authors observed an average decrease in LOS of 2.63 days from the pre-NP to post-NP period. With 122 patients in the post-NP subgroup and an average hospital bed cost of $2000 per day, a total cost savings of $641,476 per year was reported.

- **Cost-efficiency of rehabilitation (the time taken to offset the cost of rehabilitation by the resulting savings in the cost of ongoing care in the community, UK).** Turner-Stokes L, et al (2016) aimed to evaluate cost-efficiency of specialist rehabilitation for a multicentre cohort of inpatients with complex neurological disability - including stroke, comparing different diagnostic groups across 3 levels of dependency[1]. The Overall, 62 rehabilitation units provided data, with good representation across England. The mean total cost of the rehabilitation programme was £39,381 and mean savings in ongoing cost of care in the community was £496/week (2015 prices). The mean time taken to

[1] Low dependency (*The Northwick Park Dependency Score*, NPDS <10): patients are largely independent for basic self-care, Medium (NPDS 10–24): patients generally require help from one person for most self-care tasks, High (NPDS ≥25): patients require help from two or more persons for most care tasks and often also have special nursing needs. The NPDS also translates via a computerised algorithm to the Northwick Park Care Needs Assessment (NPCNA) which estimates the total care hours per week and the approximate weekly cost of care (£/week) in the community, based on the UK care agency costs.

offset the initial costs of rehabilitation was 17.9 months. Details on the methodology adopted within UKROC data set to calculate the cost-efficiency of specialist rehabilitation is reported elsewhere Turner-Stokes L, et al (2016).

- **Predictive economic modelling based on the study data:** If we assume a UK population with mean age 47 years in 2015, the average projected life expectancy would be approximately 40 years (males) and 42 years (females) (ONS 2014). The authors estimated 15-year reduction when looking at complex neurological disability, and this translated into a mean life expectancy of this study group of 25 years or more. When considering a 25-year time frame, the mean saving of about £500 per week (or £26 K per year; see Turner-Stokes L, et al (2016) in ongoing costs of care could lead to overall life-time economic gains of £650,000 or beyond per patient, or £3.7 billon for the whole study sample (2015 prices).

The individual studies for this areas of the stroke care pathway are presented in details in appendix 1.

Future economic savings from acute service reconfiguration:

Patel et al (2018) reported that centralised specialist stroke care (including APN role as part of the multidisciplinary team) can improve use of evidence based care in the first few hours after a stroke. For London, a modelling study by Hunter et al. (2013) estimated the 90-day saving to the NHS at around £800 per patient and the 10-year saving at around £3,900 per patient, and that such savings would offset reconfiguration implementation costs (estimated at around £10 million) within two years (Hunter et al, 2013).

Reconfiguration of major acute system to increase delivery of effective urgent care proved to be successful in both London and Greater Manchester (Morris et al, 2014). In London, a significantly higher proportion of patients received care according to care processes and the new model delivered a 5% relative reduction in mortality at 90 days. Both sites reported reductions in length of hospital stay.

- **Predictive economic modelling based on past successful experience**. Patel et al (2018) argued that there is scope to replicate past successful experience elsewhere. Although these findings may not be generalisable to rural areas, they are likely to be relevant for other urban areas. For example, they reported that West Midlands is another major urban region with a population size broadly equivalent to Greater Manchester's so could potentially achieve similar impact to the reconfiguration i.e. ~assuming 2.83 million population size in 2015 with 18,000 hospital days saving over 2 years (equal to £5 million saving if we assume a cost of £283 per day; Department of Health, 2015). Such saving would offset NHS intervention costs that relate to APN postgraduate training and APN salary costs for the delivery of the rehabilitation services. Details on the APN-based intervention costs are presented below.

3.2 EARLY SUPPORTED DISCHARGE TO COMMUNITY

Sources of evidence: Review of RCTs recruiting stroke patients in hospital to receive either conventional care or any service intervention that has provided rehabilitation and support in a community setting with an aim of reducing the duration of hospital care (Langhorne et al., 2017). The review findings relate to 17 trials which recruited 2,422 participants with outcomes data. The participants were on average elderly group of stroke survivors with moderate disability. In addition, we considered data published by (Fisher et al, 2015) looking to evaluate whether Early Supported Discharge (ESD) of stroke survivors is still beneficial when operating in the complex context of frontline. The authors reported on a cohort study of 293 stroke survivors recruited from two acute stroke units in Nottinghamshire and 84 caregivers. The 'Non ESD' group experienced standard practices for discharge and onward referral. Outcomes (primary: Barthel index) were assessed at baseline, 6 weeks, 6 months and 12 months. We also included the economic model published by Saka et al (2009) looking at the long-term (10 years) cost-effectiveness of stroke units (SU) care followed by ESD. Mode details on the individual studies are reported elsewhere (see appendix 2).

Patients: at least 16 years of age, stroke survivors.

Settings: in hospital stroke units.

Interventions: care provided by multidisciplinary teams that co-ordinate the transfer of care from hospital to home and provide specialist rehabilitation in the early stages back at home. The teams included contribution from registered nurses in advanced practice role.

Evidence on effectiveness of interventions: Langhorne et al (2017) reported positive outcomes for appropriately resourced ESD services with coordinated multidisciplinary team input provided for a selected group of stroke patients. Results were inconclusive for services without coordinated multidisciplinary team input. The review found that for the ESD group, initial hospital stay was reduced by approximately five days. At six months following stroke, those who received ESD were more likely to be living at home ("an extra five patients living at home for every 100 receiving ESD services; moderate-quality evidence"). They were also more likely to be independent ("an extra six patients independent for every 100 receiving ESD services; moderate-quality evidence"). No risks were reported in terms of readmission risk or patient/carer mood or quality of life. Studies reporting on coordinated ESD team appeared to report the greatest reduction in disability. Fisher et al. (2015) found that the ESD group had significantly shorter length of hospital stay ($P<0.03$) and higher levels of satisfaction with services ($P<0.01$). The ESD group had a greater chance of being independent ($\geqslant$90 Barthel Index category) at 6 weeks (56% increase in the odds of being independent), 6 months (54% increase in the odds of being independent) and 12 months (16% decrease in the odds of being independent) compared with baseline. Carers in the ESD group also showed improved mental health ($P<0.01$).

Evidence on cost-effectiveness of interventions: Saka et al (2009) compared stroke unit care followed by ESD with stroke unit care without ESD, and with general medical ward care without ESD. They used data for incident ischaemic stroke cases (N=844), observed between 2001 and 2006, from stroke units within the South London Stroke Register. Main outcome measures were societal costs (health and social care, plus lost income due to morbidity and mortality) and quality-adjusted life-years gained

(QALYs). QALYs were estimated from death status and Barthel scores, and 1-year outcomes were extrapolated to a 10-year period, assuming no stroke recurrence. They found that stroke unit care followed by ESD offered the best value for money, with a cost per QALY gain over 10 years of £10,661 compared with the general medical ward without ESD care, and £17,721 compared with the stroke unit care without ESD.

The additional quality of life benefits derived from ESD were associated with additional costs, but within the NICE acceptable threshold of £20,000 per QALY gain.

NHS England estimates for extended provision of ESD schemes following a stroke - from 20% of patients to 40% of patients – appear to suggest a potential gain of 170 lives in England and a cost saving of £15,100 per 100,000 patients (NHS England, 2014). In addition, National Audit Office data could suggest that "increasing the availability of early supported discharge from its current level to all stroke units providing early supported discharge would be cost-effective over a ten-year timeframe, costing about £5,800 per QALY gained" (National Audit Office, 2010).

The individual studies for this areas of the stroke care pathway are presented in details in appendix 2. NHS intervention costs to be invested to fund APN postgraduate training fees and APN salary costs for the delivery of rehabilitation and support in a community setting are presented below.

3.3 DISCHARGE TO SPECIALISED REHABILITATION CENTRES

Sources of evidence: Singh R et al (2017) published a prospective observational study aimed to identify the needs for specialised rehabilitation provision in a cohort of neurosurgical patients; to determine if these were met, and to estimate the potential cost implications and cost-benefits of meeting any unmet rehabilitation needs. The need for specialised rehabilitation was identified using the Patient Categorisation Tool (PCaT). Data from the unit's submission to the UK Rehabilitation Outcomes Collaborative (UKROC) national clinical database 2012-2015 were used to estimate the potential mean lifetime savings generated through reduction in the costs of on-going care in the community.

Patients: at least 16 years of age, requiring care from a neurosurgical ward (mean age was 51 years old; SD 16.4). It included 74 neurosurgical type patients with acquired brain injury due to trauma (50%), haemorrhage/stroke (39%) or tumour (11%).

Settings: in-patient (regional neurosurgical wards).

Interventions: care provided by multidisciplinary teams that co-ordinate the transfer of care from hospital to specialized centres. They included contribution from registered nurses in advanced practice role.

Evidence on cost-effectiveness of interventions: Singh R et al (2017) reported on the cost-efficiency of rehabilitation (the time taken to offset the cost of rehabilitation by the resulting savings in the cost of ongoing care in the community). Their mean length of stay was 61.9 days. Multiplying length of stay by the cost per bed-day provided by UKROC (£455 per diem), the mean episode cost of rehabilitation was equal to £28,164. The mean Northwick Park Care Needs Assessment (NPCNA)-estimated reduction in community costs of care between admission and discharge was £568 per week. The average time taken for these estimated weekly savings (related to the cost of on-going care in the community to offset the cost of the rehabilitation episode of £28,164) was calculated as 49.6 weeks (= 28,164/568), i.e. just 11.4 months.

- **Predictive economic modelling based on the study data:** The mean age of patients in the study was 51 years and the authors assumed a normal further life expectancy at this age equal to 30 years for men and 33 for women. They considered that neurological injuries may be expected to reduce life expectancy. Based on Shavelle RM, et al (2007) and Turner-Stokes L, et al (2013) they assumed that further life expectancy for patients aged 50 with 'some walking ability' is 73% of the general population, which would produce an average additional life expectancy of 22 years. According to this, a saving of £568 per week (mean NPCNA-estimated reduction in community costs of care between admission and discharge from their study) would equate to a lifetime saving in on-going care needs of approximately £650K (=568 × 52 × 22) for each

individual treated. If we subtract the cost of in-patient rehabilitation (£28,000), and we consider the cost of further community-based rehabilitation to ensure that the gains are carried over into the community (see Turner-Stokes L, et al 2013) this would still leave an approximate net lifetime saving of at least £600K per patient. Assuming a mean length of stay of 61.9 days, if we create one new neuro-rehabilitation bed, this would allow for about 6 extra patients to be treated each year. Each additional bed year provided could ideally generate up to £3.6M (=6 × £600,000) of net savings in the on-going cost of care. Such net savings would offset NHS intervention costs to be invested to fund APN postgraduate training fees and APN salary costs for the provision of specialised rehabilitation provision. New calculation of the intervention costs incurred by NHS to support the APN role are presented below.

4. MONEY THAT WOULD NEED TO BE INVESTED BY THE NHS TO DELIVER REHABILITATION SERVICES (WITH APN WORKING AS PART OF THE MULTIDISCIPLINARY CARE TEAM)

An APN in fulltime employment, with no previous experience as APN, would cost the NHS approximately £60,600 for one year of rehabilitation service delivery (table 2). Our estimates included £16,000 postgraduate training fees (incurred prior to their employment) and £44,600 salary costs for one year of fulltime job as part of the multidisciplinary team. The same APN would cost approximately £224,450 for a 5-year service delivery period (including both postgraduate training fees and salary costs for the 5 years). If the APN accumulated 5 years (or more) of experience they would cost around £67,000 for one year (and around £253,500 for 5 years) of rehabilitation service delivery (including both postgraduate training fees and salary costs).

Table 2: APN-based service delivery costs in England (including postgraduate training fees and fulltime salary for one advanced practice nurse working as part of the multidisciplinary team; 2019 values)

	Duration of rehabilitation service provision*		
Level of experience	**One year**	**Two years**	**Five years****
SCENARIO 1: < 1 year	£ 60,606	£ 103,704	£ 224,447
SCENARIO 2: 1 - 2 years	£ 60,606	£ 103,704	£ 225,951
SCENARIO 3: 2 - 3 years	£ 60,606	£ 103,704	£ 230,854
SCENARIO 4: 3 - 4 years	£ 62,331	£ 107,095	£ 237,903
SCENARIO 5: 4 - 5 years	£ 64,324	£ 111,014	£ 241,822
SCENARIO 6: 5+ years	£ 66,819	£ 115,919	£ 253,481

* We assumed that the postgraduate training fees (MSc plus bolt on module) and the salary costs (NHS pay scale Band 8a, fulltime employment) that would need to be invested to deliver APN-based rehabilitation services were comparable across the three overarching areas of the stroke care pathway (i.e. emergency/acute care services, early supported discharge to community, and discharge to specialised rehabilitation centres). **We adjusted for any salary increase that may apply according to the level of experience accumulated within the 5 years.

5. CONCLUSIONS

Stroke rehabilitation involves a multidisciplinary approach, with nurses performing a central role. Investing in an advanced practice role for nurses to increase patients' access to multidisciplinary rehabilitation service can be beneficial and bring better health outcomes, patient satisfaction and economic savings. This applies across different areas of the pathway of care when treating young adult with stroke.

- **EMERGENCY AND CRITICAL CARE SETTINGS**. There is evidence to suggest that the implementation of advanced practice nursing roles in the emergency and critical care settings improves outcomes.
    - **In emergency setting**, APN-based rehabilitation interventions report decreased waiting time to consultation (and to treatment), increased patient satisfaction and comparable length of stay (compared with usual care with no APN role as part of the multidisciplinary team).

    - **In critical care setting**, APN-based rehabilitation intervention report decreased waiting time to treatment, increased patient satisfaction and comparable mortality data than the comparator (rehabilitation model with no APN role). When looking at the subgroup of patients in greater need of communication with multidisciplinary teams, discharge planning, care coordination, and demanding more administrative work, the patients managed according to multidisciplinary collaborative model with APN performed better (in terms of shorter length of stay) than the comparator.
- The transformation of healthcare delivery through effective utilization of the APN workforce may reduce demand for health services use and attached costs. Specialist rehabilitation with APN role can be cost-saving, especially for high-dependency patients. **The implementation of acute service reconfiguration (to include centralised specialist stroke care with APN role as part of the multidisciplinary team)** proved to be successful in different urban regions. For example, if we assume an urban centre like Greater Manchester with a population size of about 3 million service reconfiguration would achieve about 18,000 hospital days saving over 2 years (equal to £5 million saving in NHS money).

- **REHABILITATION AND SUPPORT IN A COMMUNITY SETTING**. There is evidence that ESD services for stroke patients with multidisciplinary team input (including APN role) can reduce long-term dependency and admission to institutional care as well as reducing the length of hospital stay. Economic modelling comparing stroke unit care followed by ESD with stroke unit care without ESD (and with general medical ward care without ESD) found that stroke unit care followed by ESD offered the best value for money, well within the NICE acceptable threshold of cost-effectiveness.

- **DISCHARGE TO SPECIALISED REHABILITATION CENTRES**. A preliminary single-centre study identified a considerable gap in provision of specialised

rehabilitation for neurosurgical patients (including stroke patients), which must be addressed if patients are to fulfil their recovery. Estimates of the potential cost implications and cost-benefits of meeting any unmet rehabilitation needs showed that each additional bed year provided could ideally generate up to £3.6 million of annual net savings in the on-going cost of care.

APN-based interventions that generate such important gains in health outcomes, patient satisfaction, and economic benefits require greater priority in NHS postgraduate training for registered nurses aspiring to become APNs. Published economic modelling reported that NHS costs invested for the provision of staff training (and service delivery to support APN role as part of the rehabilitation team) would be well offset by the NHS savings deriving from the additional bed-year provided. Our report provides preliminary figures on the APN-based service delivery costs in England and their variation according to staff experience and length of service provision.

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7. APPENDICES

Appendix 1: Summary of evidence on advanced practice nursing role for adults or young people of 16 years old attending acute care/ in-patient rehabilitation

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
ANP-directed care (ANP only)	Colligan et al. (2011)	New Zealand	High according to Woo et al 2017 – Quality assessment was based on the "JBI Critical Appraisal Checklist for Randomized Controlled Trials," and "JBI Critical Appraisal Checklist for Cohort Studies".	To determine if emergency NPs (ENPs) were equivalent to emergency medicine (EM) registrars in managing minor injuries	ED of a tertiary hospital	Prospective cohort study	Patients > 15 years presenting with trauma (n = 420)	Intervention (n = 305): ENP. Median age 30; 70% male; 62% Caucasian; 81% triage 4; 35% procedures performed. Comparator (n = 115): EM registrars. Median age 41; 59% male; 66% Caucasian; 72% triage 4; 32% procedures performed.	ENP managed minor injuries. ENP administered anesthetic and rendered treatment procedure as required independently.	ED length of stay (LOS)	For patients who underwent procedures for their minor injuries, significant difference between study groups in the median LOS was present, 92 min (IQR 62–132) in NP group versus 135 min (96–200) in Registrars group (Mann-Whitney U test P < 0.01). For patients who did not undergo any procedures, significant difference between study groups in the median LOS was also present, 119 min (IQR 68–154) in NP group versus 135 min (118–214) in Registrars group (Mann-Whitney U test P < 0.01).	• A New Zealand study conducted at a single site. • Registrars took a longer time to see these minor injuries patients as the patients were of higher acuity with comorbidities while the ENP reviewed the straightforward minor injury cases. • NPs tend to complete patient care on their own while Registrars would delegate discharge or administrative tasks to clerical staff. • The time recorded electronically might not have been precise in reflecting the patient's transit times. It was possible NPs logged onto the system to review patients faster than Registrars which might have account for the reduced LOS for NP-treated patients.

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
	See above	See above	See above	See above	See above	See above	See above	See above	See above	Waiting time (Time to consultation /Time to treatment) - Emergency setting	Significant difference between study groups in median time to consultation, 14 min (IQR 5–27) in NP group versus 50 min (IQR 21–78) in Registrars group (Mann-Whitney U P < 0.0001).	See above
	David et al. (2015)	USA	Medium according to Woo et al 2017 2017 – Quality assessment criteria see above	To determine if the addition of a cardiac acute care NP (ACNP) to care teams could improve utilization outcomes	Cardiovascular ICU (CCU) of a large urban and academic medical center	Retrospective cohort study	Patients admitted directly to the CCU with the primary diagnosis of either ST or non-ST segment elevation myocardial infarction (non/STEMI) or heart failure (HF) (n = 185)	Intervention (n = 109): Cardiac ACNP in collaboration with CCU physician house staff team. Mean age 69.2; 62.4% male; 28.4% HF; 71.6% non/STEMI. Comparator (n = 76): CCU physician house staff team. Mean age 70.6; 65.8% male; 26.3% HF; 73.7% non/STEMI.	Cardiac ACNP and physician worked together within a multidisciplinary team. Responsibilities of ACNP include routine medical care, discharge planning, care coordination, patient education on disease process and self-care, and post-discharge telephone follow-ups.	30-day return to ED; 30-day readmission rate; LOS; time of discharge	No significant difference found between study groups in the mean LOS in the inpatient telemetry cardiology unit and ICU, 129.1 ± 96.7 h in NP collaborative group versus 119.1 ± 69.7 h in physician-only group (P = 0.469).	• A USA study conducted at a single site. • Advocates for the NP collaborative model of care as it provides the unit staff with a consistent point of contact for the multidisciplinary team. • The NP collaborative model of care allows for NPs to develop expertise for managing a specific group of patients.
	Dinh et al. (2012)	Australia	Medium according to Woo et al 2017 –	To compare the quality of care	Fast-track unit within the ED	RCT	Patients between age 16 and 70 years	Intervention (n = 133): ENP. Median age 37; 60% male; 73%	ENP worked independently, assessed and managed	Patient satisfaction scores; follow-up health	Significant difference between study groups in overall rating	• An Australian study conducted at a single site. • Lost to follow-up rates was high. The waiting time of

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
			Quality assessment criteria see above	provided by an ENP and emergency doctors	of a suburban hospital		presenting to the ED with Australasian Triage Scale (ATS) category 4 or 5, who had normal vital signs and mental state, without complex medical or surgical comorbidities, and did not require multiple diagnostic tests or specialty consultations (n = 233)	musculoskeletal presenting problem. Comparator (n = 103): ED doctors ranged from resident medical officers, emergency registrars, career medical officers, and emergency physicians. Median age 33; 64% male; 71% musculoskeletal presenting problem.	patients within the fast-track unit, and consulted senior medical staff when required.	status at 2-week follow-up; adverse events (readmission to ED within 14 days or missed fractures); waiting time to be seen	categories. A higher proportion (68%) of patients in the NP group rated their care as excellent compared to the doctor group (50%) (Fisher exact test, P = 0.02). Significant difference between study groups in total patient satisfaction score, median score 23 (IQR 20–24) in NP group versus median score 21 (IQR 16–24) in doctor group (Students t test, P = 0.002). No significant difference between study groups in median waiting time to be seen, 50 min (IQR 33–77) in NP group versus 57 min (IQR 31–110) in doctor group (P = 0.06).	patients who left before being seen was not captured. • Patients in both study groups had similar baseline characteristics. • Patients seen by NP and doctors had comparable waiting time to consultation.
	Goldie et al. (2012)	Canada	Medium according to Woo et al 2017 – Quality assessm	To compare the effectiveness of ACNP-led care to	Post-operative cardiac surgery unit in a	RCT	Patients ≥ 18 years who had been scheduled for either urgent or	Intervention (n = 22): ACNP-led post-operative care, guided by	The ACNP functioned solely as a clinician, performs focused physical	LOS; hospital readmission within 60 days; post-operation	No significant difference found between study groups in the mean hospital LOS, 9 ± 6 days in NP group	• A Canadian RCT conducted at a single site. • Total sample size varied during the statistical analysis as there were varying

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
			ent criteria see above	hospitalist-led (physicians trained in general medicine) care in a post-cardiac surgery patients	tertiary hospital		elective coronary artery bypass graft (CABG) and/or valvular surgery (n = 103).	previously established clinical pathway. Mean age 67; 86% male; 85% urgent procedure; 71% CABG. Comparator (n = 81): Hospitalist-led post-operative care, guided by previously established clinical pathway. Mean age 65; 81% male; 43% urgent procedure; 62% CABG.	assessments and comprehensive health history-taking, and reviewed the patients' medications and diagnostic tests to develop care plans for the patients to augment established clinical pathway. Upon discharge, the ACNP communicated with the family physician of patients whom she anticipated complications post-discharge to discuss plan of care for the patient.	complications; attendance at cardiology or cardiac rehabilitation appointments; overall patient satisfaction; overall team satisfaction	versus 9 ± 14 days in hospitalist group (t test, P = 0.87). No significant difference between study groups in mean overall patient satisfaction score, 103 ± 11 in NP group versus 97 ± 14 in hospitalist group (independent t test, P = 0.10).	amounts of missing data. • A much higher proportion of male participants recruited (86% in NP group and 81% in hospitalist group) raised queries about system level factors that might have favored male participants and the general willingness of female patients to participate in research. • The patient acuity in NP group was higher than that in hospitalist group and yet the groups did not differ in their clinical outcomes.
	Hiza et al. (2015)	USA	Medium according to Woo et al 2017 – Quality assessment criteria	To analyze the effect of an orthopedic trauma NP on LOS and cost	Level I trauma center	Retrospective cohort study	Patients who were treated operatively and non-operatively or who were transferre	Intervention (n = 871): NP as an additional member of the orthopedic trauma team.	A single full-time NP added to the orthopedic trauma team. The NP assisted the	LOS; cost	No significant difference found between study groups in mean LOS, 4.91 ± 4.53 days in the NP collaborative group versus	• A USA study conducted at single site. • After subgroup analysis, significant differences in LOS were found between study groups in patients transferred

Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
		see above				d from other services to the orthopedic trauma team and who were then discharged from the orthopedic trauma team (n = 1 584)	80.25% <60 years; 64.41% ED admission. Comparator (n = 713): Orthopedic trauma team without NP. 85.27% <60 years; 76.6% ED admission.	orthopedic intern in daily floor work such as arranging social service needs, discharge planning, and paperwork. The NP acted as a liaison for the orthopedic trauma team in daily multidisciplinary meetings between other physicians, allied health professionals, nurse managers, and social workers.		6.02 ± 6.74 days in the physician group (Wilcoxon P = 0.1441). Averagely, US$ 2 000 is incurred per day for hospitalization. For the subgroup of patients discharged to rehabilitation facility, a decrease in 2.63 days in the collaborative NP group of 122 patients could yield a cost savings of US$ 641 476 per year. For the subgroup of patients transferred from another service, similar cost analysis generated a total savings of US$ 1 059 480 per year. For the subgroup of patients who are 60 years and above, similar cost analysis generated a savings of US$ 790 240 per year. For the subgroup of patients discharged on IV	from another service (Wilcoxon P < 0.0001), patients discharged to rehabilitation facility (Wilcoxon P = 0.0024), patients older than 60 years (Wilcoxon P = 0.0369), or patients discharged on intravenous antibiotics/wound therapy (Wilcoxon P = 0.0171). A significantly lower mean LOS was found in the NP collaborative group. • In this subgroup of patients, greater communication with multidisciplinary teams, discharge planning, follow-up care coordination and administrative work were required. This demonstrated the value of adopting the NP collaborative model of care.

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
											antibiotics or wound therapy, similar cost analysis generated savings of US$ 478 240 per year.	
	Hoffman et al. (2006)	USA	Medium according to Woo et al 2017 – Quality assessment criteria see above	To compare the outcomes of patients when medical management was provided by an attending physician in collaboration with a unit-based ACNP or an attending physician and critical care/pulmonary care fellows who rotated coverage	Subacute medical ICU (MICU) of a university medical center	Prospective cohort study	Patients admitted to the subacute MICU who required prolonged mechanical ventilation (≥ 7 days) with tracheostomy (n = 192)	Intervention (n = 98): An attending physician in collaboration with a unit-based ACNP. Mean age 61.9; 51% male; 85.6% white; 56.1% acute pulmonary diagnosis. Comparator (n = 94): An attending physician and critical care/pulmonary care fellows who rotated coverage. Mean age 61.2; 53.2% male; 87.1% white; 48.9% acute pulmonary diagnosis	The ACNP was responsible for assessment, diagnosis, and documentation of patient care, including weaning and extubation. The ACNP was responsible for the admission of patients and discharge decisions. During the rounds, the attending physician would review and revised the plan of care.	ICU LOS; days on mechanical ventilation; readmissions to MICU; ICU mortality	No significant difference between study groups in the mean ICU LOS, 14.6 ± 9.7 days in NP collaborative group versus 15 ± 11.4 days in non-NP group (P = 0.753). No significant difference between study groups in ICU mortality, 2% in NP collaborative group versus 2% in non-NP group without treatment limitation (Fisher's exact test P = 1.0).	• A USA study conducted at a single site. • The comparable ICU LOS between NP collaborative model of care and the model of care without NP might be due to the greater continuity of care rendered by the NP as compared to the rotating coverage of the fellows in the non-NP model of care. • It might also be contributed by the attending physician's ability to provide expert supervision and direct care of the patients, despite the difference in the composition of the team. • It could also be because the NP was highly experienced and was familiar with the environment and the patient care demands.
	Jennings et al. (2008)	Australia	Medium according to Woo et	To assess the impact of the	Emergency and trauma center	Retrospective cohort study	Adult patients in ATS categories	Intervention (n = 572): ENPC completed	ENPC are nurses who are practicing	LOS	Significant difference between study groups in the	• An Australian study conducted at a single site. • Patients in the ENP candidate

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
			al 2017 – Quality assessment criteria see above	implementation of ENP candidate (ENPC) on waiting times and LOS for patients presenting to the ED			3 to 5 (n = 3 156)	care of patient. 6.1% ATS 3; 63.7% ATS 4; 30.2% ATS 5. Comparator (n = 2 584): Medical officer completed care of patient with assistance from nurses. 19.5% ATS 3; 58.4% ATS 4; 22.1% ATS 5.	within the role and seeking accreditation as NPs. The ENPC completed the care for each presenting patient from initial assessment, intervention, prescribing, diagnosis, treatment, and disposition within a collaborative ED team using Clinical Practice Guidelines for each presentation.		median ED LOS, 94 min (IQR 53.5–163.5) in the ENP candidate group versus 170 min (IQR 100–274) in the medical officers group (Wilcoxon P < 0. 001).	group were from the Fast Track unit where patients of lower acuity were seen. Patients in the medical officers group were not only from the Fast Track unit. The medical officers might have reviewed more complex cases and hence, required more time.
	See above	See above	See above	See above	See above	See above	See above	See above	See above	time to be seen	No significant difference between study groups in median time to consultation, 12 min (IQR 5.5–2.8) in the ENP candidate group versus 31 min (IQR 11.5–76) in medical officer group (Wilcoxon P < 0. 001).	See above

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
	Jennings et al. (2015)	Australia	High according to Woo et al 2017 – Quality assessment criteria see above	To compare the effectiveness of NP service with standard medical care in the ED	ED of a major referral hospital	Pragmatic RCT	Adult patients presenting with verbal numeric pain scale score > 1 and in ATS categories 2 to 5 (n = 258)	Intervention (n = 130): NPs managed patient care with assistance if necessary from a registered nurse. Mean age 30; 53% male; 66% ATS 4. Comparator (n = 128): Medical officers managed patient care with assistance from a registered nurse. Mean age 33; 61% male; 63% ATS 4.	The ENP manages the care of the patient. After the initial assessment, the ENP initiated the management of the patient and completed the episode of care. Analgesics were prescribed by NPs when required.	Proportion of patients who received analgesia within 30 min; time to analgesia from ED arrival; changes in pain score; documentation of pain scores	Significant difference between study groups in the proportion of patients receiving analgesia within 30 min of ED arrival, 15.4% in NP group versus 1.6% in medical officer group (Chi-square test P < 0.001).	• An Australian study conducted at a single site. • NP group performed better at complying with the recommended Australian national targets for administering timely analgesia. • NP provided a hybrid model of care, assimilating nursing, and medical tasks. The NP could perform patient assessment, order and administer the analgesia which reduced the time to treatment.
	Landsperger et al. (2016)	USA	High according to Woo et al 2017 – Quality assessment criteria see above	To evaluate the safety of the continuous in-house ACNP care as compared to in-house resident care	MICU of a university hospital	Prospective cohort study	Adult patients admitted to a MICU team (n = 9 066)	Intervention (n = 2366): Team led by ACNP, supervised by critical care fellows and attending physicians. Mean age 55.9. 51% male; 78% Caucasian; 53% ED admission; 28% mechanical	The ACNP was responsible for the evaluation and management of patients. Responsibilities included conducting admissions, transfers, discharges, obtaining and interpreting	90-day survival; ICU LOS; hospital LOS; ICU mortality; hospital mortality; longer term mortality	Significant difference between study groups in median ICU LOS, 3.4 ± 3.5 days in NP group versus 3.7 ± 3.9 days in Resident group (Wilcoxon P < 0.001). Similar odds of a longer ICU stay between groups (odds ratio 1.01, 95% CI 0.93–1.1, P = 0.81) Significant	• An USA study conducted at a single site. • Large prospective cohort study (n = 9066). • Patients in NP group were solely managed by NPs and the supervising attending physicians and fellows. There was no cross-contamination, the Residents did not interfere with the management of patients in the NP group. • Even though

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
								ventilation; 27% vasopressors. Comparator (n = 6 700): Team led by 1st year resident and 1 upper level resident, supervised by critical care fellows and attending physicians. Mean age 56.7; 52% male; 76% Caucasian; 52% ED admission; 33% mechanical ventilation; 36% vasopressors.	diagnostic tests, and performing critical care procedures with supervision of critical care fellows and attending physicians.		difference between study groups in median hospital LOS, 7.9 ± 11.2 days in NP group versus 9.1 ± 11.2 days in Resident group (Wilcoxon P < 0.001). NP group had lower odds of a longer ICU stay compared to Resident group (odds ratio 0.87, 95% CI 0.80-095 P = 0.001). No significant difference between study groups in ICU mortality (adjusted odds ratio 0.77, 95% CI 0.63-.94, P = 0.1). No significant difference between study groups in hospital mortality (adjusted odds ratio 0.87, 95% CI 0.73-1.03, P = 0.11) No significant difference between study groups in 90-day mortality (adjusted odds	LOS findings between study groups favour the NP group, the lack of clear definition of the role of the acute care NP hinders direct comparison of clinical outcomes with the residents. • Hospital LOS for NP group was shorter than Resident group as more patients were being discharged straight from the ICU in NP group. It could have been due the differences in patient's diagnosis, social or financial situations, or provider practice paradigm. • Shorter hospital LOS in NP group did not come at the expense of longer ICU LOS, increased ICU readmissions or post-discharge mortality. • A higher patient to provider ratio was observed in NP group but the authors were judicious in inferring that NP-led model of care had greater efficiency given the differences in the patients' characteristics between study groups.

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
											ratio 0.94, 95% CI 0.83–1.07, P = 0.36). No significant difference between study groups in longer term mortality (adjusted odds ratio 1.03, 95% CI 0.92–1.1 P = 0.65).	
Collaborative care (ANP + specialist doctor/ multidisciplinary team)	Moran et al. (2016)	USA	Medium according to Woo et al 2017 – Quality assessment criteria see above	To evaluate if the introduction of 24/7, on-site coverage with a neurocritical ACNP as first responders for acute "stroke code" would shorten time to treatment and improve compliance with acute stroke time targets	Stroke center of a tertiary hospital	Retrospective cohort study	Adult patients with the principal diagnosis of acute ischemic stroke (n = 168)	Intervention (n = 122): On-call neurovascular physician and 24/7 ACNP first responder coverage for the hospital stroke code team. Median age 73; 49% male; 48% Asian; 77% hypertension. Comparator (n = 44): On-call vascular neurologist or neuro intensivist had a 30-min window for arrival to the bedside after the stroke code team was activated. Median age 68; 54%	The ACNP took initial history, obtained the National Institutes of Health Stroke Scale (NIHSS) score, obtain and review imaging, review the indications and contraindications for tissue plasminogen activator (tPA), and discussed tPA eligibility with the on-call vascular neurologist by telephone. For patients who were ineligible for tPA, the	Onset-to-needle time; imaging-to-needle time; door-to-needle time; hospital mortality	Significant difference between study groups in median door-to-needle time for acute ischemic stroke, 45 min (IQR 35–58) in NP group versus 53 min (IQR 45–73) in non-NP group (Mann-Whitney U P = 0.001). No significant differences between study groups in hospital mortality, 12% in NP group versus 18% in non-NP group (chi-square test, P = 0.33).	• A USA study conducted at a single site. • Stroke code care pathway remained the same during the intervention period. • The reduced time interval between diagnostic imaging and the administration of treatment contributed to the reduction in door-to-needle time. • NP group was reviewed earlier upon stroke code activation as the NP service was 24/7. Necessary assessments commenced earlier.

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
								male; 48% Asian; 77% hypertension.	ACNP documented the clinical encounter. For patients who were eligible for tPA, the on-call vascular neurologist directly evaluated the patient and made the final decision regarding tPA administration.			
	Morris et al. (2012)	USA	High according to Woo et al 2017 – Quality assessment criteria see above	To determine if there were differences between the care provided by unit-base NP (UBNP) and residents	Level 1 trauma center	Retrospective cohort study	Adult patients requiring trauma service (n = 3 859)	Intervention (n = 2 759): UBNP care of trauma patients led by trauma attending physicians. Mean age 42.4; 72% male; 52% African American. Comparator (n = 1 100): Resident care of trauma patients led by trauma attending physicians. Mean age 42.6; 70% male; 54%	A group of NPs provided direct daily care, supervised by the trauma attending physician. Resident involvement with the patients admitted to the UBNP floor is limited to invasive procedures and overnight cross-coverage.	ICU admission; LOS; complications; readmissions	No significant difference between study groups in mean LOS, 6.5 ± 8.8 days for NP group versus 7 ± 10.8 days for Resident group (t test P = 0.17).	• A USA study conducted at a single site. • Although the results are not statistically significant, they were clinically important. The difference of 0.5 days multiplied by the number of patients in NP group (2759) accumulates to a total difference of greater than 1300 patient days. • A greater proportion of Resident group discharged to other health facilities which was delayed by bed availability. This could be a possible reason for the longer hospital LOS for patients in

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
								African American.				Resident group. • Daily multidisciplinary rounds were scheduled in NP group but not in Resident group which could have improved the coordination of patient care, contributing to shorter LOS.
	Roche et al. (2017)	Australia	Medium according to Woo et al 2017 – Quality assessment criteria see above	To examine the safety and quality of ENP service in the provision of care and the effectiveness of ENP service for adults with chest pain	EDs of 3 rural hospitals	Prospective cohort study	Patients ≥ 18 years presenting with chest pain that was not a result of an acute injury (n = 61)	Intervention (n = 23): ENP model. Mean age 59.9; 30% male. Comparator (n = 38): Standard care model (care delivered and coordinated by medical officer). Mean age 61.7; 50% male.	The ENP managed the patient presenting with undifferentiated chest pain. The ENP delivered and coordinated care in diagnosis, investigation, therapeutic treatment, and referral.	Adherence to guidelines; diagnostic accuracy of ECG interpretation; waiting times; LOS; LWOT; diagnostic accuracy as measured by unplanned representation rates; patient satisfaction; quality-of-life; functional status	No significant difference between study groups in median LOS, 97.0 min (IQR 91) in NP group versus 101.5 min (IQR 54) in medical officer group (Mann-Whitney U test P = 0.8). No significant difference between study groups in median waiting time, 8 min (IQR 23) in NP group versus 7.5 min (IQR 20) in medical officer group (Mann-Whitney U test P = 0.4). No significant difference between study groups in patient satisfaction of care at the occasion-of-	• An Australian study conducted at three rural EDs. • Small sample size, underpowered study. • No significant differences between groups in baseline characteristics or acuity, NP service was comparable to that of senior medical officers.

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
											service (Fisher's exact test, P = 0.96). No significant difference between study groups in patient satisfaction of care at follow-up (Fisher's exact tests, P = 0.98).	
	Scherzer et al. (2016)	USA	Medium according to Woo et al 2017 – Quality assessment criteria see above	To compare usage patterns and outcomes of a NP-staffed MICU and a resident-staffed physician MICU	MICU of a large urban university hospital	Retrospective cohort study	Patients admitted to the adult MICU (n = 1 157)	Intervention (n = 221): NP-staffed MICU. Mean age 62.3; 53.8% male; 64.3% White; 39.4% respiratory failure. Comparator (n = 936): Resident-staffed MICU. Mean age 59.2; 55.8% male; 56.1% White; 32.8% respiratory failure.	Daytime staffing consisted for 2 internal medicine residents and two NPs, supervised by an attending critical care physician. Night-time coverage consisted of 1 NP with 1 critical care fellow.	MICU mortality; hospital mortality; MICU readmission; MICU LOS; hospital LOS; post-MICU discharge LOS; charges observed	Significant difference between study groups in mean MICU LOS, 7.9 ± 7.5 days in NP group versus 5.6 ± 6.5 days in Resident group (Wilcoxon P < 0.0001). No significant difference between study groups in mean hospital LOS, 18.0 ± 16.8 days in NP group versus 15.9 ± 19.9 days in Resident group (Wilcoxon P = 0.435). No significant difference between study groups in mean post-MICU discharge LOS, 6.4 ± 8.7 days in NP group versus 8.4 ± 15.6 days	• A USA study conducted at a single site. • Presence of differing clinical practice between NP and Residents could have contributed to the difference in MICU LOS. • Patients in NP group were older, more chronically and critically ill than patients in Resident group and so were more likely to require longer MICU care. • Patients in NP group had higher likelihood of being discharged to a post-acute care setting compared to patients in Resident group. The availability of the discharge facility could have attributed to MICU LOS.

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
											in Resident group (Wilcoxon P = 0.102). No significant difference between study groups in MICU, 14.5% in NP group versus 13.1% in Resident group (adjusted odds ratio 0.8, P = 0.441). No significant difference between study groups in hospital mortality, 24.4% in NP group versus 24.8% in Resident group (adjusted odds ratio 0.7, P = 0.072). No significant difference in charges observed between study groups, US$ 242 324.03 ± 23 5 749.24 in collaborative NP group versus US$ 216 726.51 ± 26 2 021.77 (t test, P = 0.561).	
	Skinner et al. (2013)	UK	Medium according to Woo et	To assess the feasibility and safety	Cardiac ICU of a tertiary hospital	Retrospective cohort study	Patients admitted to an adult	Intervention (n = 678): NP providing first-line	Model of care included NPs in the team	ICU mortality; annual staffing cost	No significant difference between study groups in ICU	• A UK study conducted at a single site. • A reduction of staffing costs was

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
			al 2017 – Quality assessment criteria see above	of NPs providing first-line care on an ICU with all doctors becoming non-resident at night			cardiac ICU (n = 1 380)	care. Comparator (n = 702): Junior resident doctors providing first-line care.	and resident NP providing first-line care after evening rounds. Non-resident doctors remain within 15 min of the hospital.		mortality, 2.8% in NP group versus 2.2% in junior resident group (chi-square test, P = 0.43). Annual staffing cost of NP and junior residents was £933 344 with the usual model of care and £764 691 with the collaborative NP model of care.	observed. • Uncertain of how cost analysis was done.
	Steiner et al. (2009)	Canada	Medium according to Woo et al 2017 – Quality assessment criteria see above	To determine if the addition of a broad-scope NP would improve wait times, ED LOS and left-without-treatment (LWOT) rates	Urban community ED	Prospective cohort study	Patients requiring ED services (n = 3 238)	Intervention (n = 1 924): NP collaborative visits or NP autonomous visits. Comparator (n = 1 314): Emergency physician (EP) visits.	The NP collaborative model was like that of residents, with the EP retaining the ultimate decision-making authority. The NP also provided health promotion and counselling. EP delegated specific discretionary tasks such as direct patient care, discharge planning and follow-up arrangemen	Wait times; ED LOS; LWOT	No significant difference between study groups in median ED LOS, 125 min (IQR 78–192) in NP group versus 123 min (IQR 76–184) in physician group (Wilcoxon P = 0.13). No significant difference between study groups in median time to consultation, 61 min (IQR 34–99) in NP group versus 65 min (IQR 35–105) in physician group (Wilcoxon P = 0.62).	• A Canadian study conducted at a single site. • The emergency physician group had patients of higher acuity than NP collaborative group yet there was no difference in LOS between groups, possibly implying it was more efficient to do without collaboration with NPs. • However, the demand for physicians to review lower acuity patients might have reduced with the collaborative NP group, allowing physicians to spend more time with higher acuity patients.

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
									ts to an NP. In the NP autonomous scope of practice, it was limited to patients in categories 4 and 5 of the Canadian ED Triage and Acuity Scale (CTAS).			
	Turner-Stokes L, et al (2016)	UK	Medium – Quality assessment criteria see above	To evaluate functional outcomes, care needs and cost-efficiency of specialist rehabilitation for a multicentre cohort of inpatients with complex neurological disability - including stroke, comparing different diagnostic groups across 3 levels of dependency.	in hospital service	Prospective cohort study - non-interventional observational study	All 62 specialist (levels 1 and 2) rehabilitation services in England. Patients n= 5739	Intervention: Specialist inpatient multidisciplinary rehabilitation. Control: non-interventional observational study	Specialist inpatient multidisciplinary rehabilitation	Dependency and care costs: Northwick Park Dependency Scale/Care Needs Assessment (NPDS/NPCNA). Functional independence: UK Functional Assessment Measure (UK Functional Independence Measure (FIM)+FAM). Cost-efficiency: (1) time taken to offset rehabilitation costs by savings in NPCNA-estimated	Mean LOS 90.1 (SD 66) days. All groups showed significant reduction in dependency between admission and discharge on all measures (paired t tests: $p<0.01$). Mean reduction in 'weekly care costs' was greatest in the high-dependency group at £760/week (95% CI 726 to 794)), compared with the medium-dependency (£408/week (95% CI 370 to 445)), and low-dependency (£130/week (95% CI 82 to 178)), groups. Despite longer	Large cohort analyses of routinely collected outcome data in UK. The NPCNA estimates of continuing care costs are not true assessments as applied in traditional health economic studies, although for the purpose of this study the focus is in the relative values for between-group comparison than the absolute values. While rehabilitation is provided through the health sector, the saving in care costs accrues to those responsible for ongoing care (typically the social care services or the patient and their family). Thus, the actual opportunity for realisation and reinvestment of the savings will depend

	Reference	Country	Study quality	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results	Comments
										costs of ongoing care, (2) FIM efficiency (FIM gain/LOS days), (3) FIM+FAM efficiency (FIM+FAM gain/LOS days). Patients were analysed in 3 groups of dependency	LOS, time taken to offset the cost of rehabilitation was 14.2 (95% CI 9.9 to 18.8) months in the high-dependency group, compared with 22.3 (95% CI 16.9 to 29.2) months (medium dependency), and 27.7 (95% CI 15.9 to 39.7) months (low dependency). FIM efficiency appeared greatest in medium-dependency patients (0.54), compared with the low-dependency (0.37) and high-dependency (0.38) groups. Broadly similar patterns were seen across all 4 diagnostic groups.	on the local funding arrangements for health and social care.

Data extracted from: Woo BFY, Lee JXY, Tam WWS. The impact of the advanced practice nursing role on quality of care, clinical outcomes, patient satisfaction, and cost in the emergency and critical care settings: a systematic review. Hum Resour Health. 2017;15(1):63.

Appendix 2: Summary of evidence on early supported discharge services (to community) for adults or young people of 16 years old with acute stroke

Reference	Country	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results Relative effect (95%CI)	Quality of the evidence	Comments
Langhorne et al., 2017	Multiple	To establish if, in comparison with conventional care, services that offer people in hospital with stroke a policy of early discharge with rehabilitation provided in the community (ESD) can: 1) accelerate return home, 2) provide equivalent or better patient and carer Outcomes, 3) be acceptable satisfactory to patients and carers, and 4) have justifiable resource implications use.	in hospital	Systematic review of the literature Randomised controlled trials (RCTs)	stroke patients	conventional care	any service intervention that has provided rehabilitation and support in a community setting with an aim of reducing the duration of hospital care	Death or dependency at end of scheduled follow-up (median 6 months)	OR 0.80 (0.67 to 0.95)	Moderate - according to GRADE Working Group grades of evidence	Assumed risk from Baseline in included trials. Corresponding risk estimated from risk difference (95%CI)
See above	See above	See above	See above	See above	See above	See above	See above	Death at end of scheduled follow-up (median 6	OR 1.04 (0.77 to 1.40)	Moderate - according to GRADE Working	See above

Reference	Country	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results Relative effect (95%CI)	Quality of the evidence	Comments
								months)		Group grades of evidence	
See above	See above	See above	See above	See above	See above	See above	See above	Death or institution care at end of scheduled follow-up (median 6 months)	OR 0.75 (0.59 to 0.96)	Moderate - according to GRADE Working Group grades of evidence	See above
See above	See above	See above	See above	See above	See above	See above	See above	Extended activities of daily living (EADL) score at end of scheduled follow-up (median 6 months)	SMD 0.14 (0.03 to 0. 25)	Low - according to GRADE Working Group grades of evidence	See above
See above	See above	See above	See above	See above	See above	See above	See above	Satisfaction with services at end of scheduled follow-up (median 6 months)	OR 1.60 (1.08 to 2.38)	Low - according to GRADE Working Group grades of evidence	See above
See above	See above	See above	See above	See above	See above	See above	See above	Length of initial hospital stay (days)	MD - 5.5 (2.9 to 8.2) days	Moderate - according to GRADE Working Group grades of evidence	See above
See above	See above	See above	See above	See above	See above	See above	See above	Readmission to hospital at end of scheduled follow-up (median 6 months)	OR 1.09 (0.79 to 1.51)	Low - according to GRADE Working Group grades of evidence	See above
Fisher et al (2016)	UK	To evaluate whether early Supported	UK	cohort study with quasi experimenta l design	stroke survivors (transfer independentl	Standard practices for discharge	the 'ESD' group (=multidiscip linary teams	Barthel Index for users and carers,	The ESD group had a significantly shorter	n/a	Not all patients, accessing the two

Reference	Country	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results Relative effect (95%CI)	Quality of the evidence	Comments
		Discharge (ESD) of stroke survivors is still beneficial when operating in the complex context of frontline healthcare provision.			y or with assistance of one, identified rehabilitatio n goals) within two naturally formed groups were recruited from two acute stroke units	and onward referral	that co-ordinate the transfer of care from hospital to home and provide specialist rehabilitatio n in the early stages back at home) accessed either of two ESD services operating in Nottinghams hire, UK	length of hospital stay, satisfaction with services received	length of hospital stay (P=0.029) and reported significantly higher levels of satisfaction with services received (P<0.001). Following adjustment for age differences at baseline, participants in the ESD group (n=71) had significantly higher odds (compared to the Non ESD group, n=85) of being in the ⩾90 Barthel Index category at 6 weeks (OR = 1.557, 95% CI 2.579 to 8.733), 6 months (OR = 1.541, 95% CI 2.617 to 8.340) and 12 months (OR 0.837, 95% CI 1.306 to 4.087) respectively in relation to baseline.		Early Supported Discharge services we studied, were recruited to this study. There was a slower stream of patients (not involved in this study) who took longer (than the 14-days post stroke recruitment window used) to reach eligibility criteria for the two services. Another limitation of this study was its quasi experimental nature. Both services in this study have adopted core components of an evidenced base service (informed by an international Early Supported Discharge

Reference	Country	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results Relative effect (95%CI)	Quality of the evidence	Comments
									Carers of patients accessing ESD services showed significant improvement in mental health scores (P<0.01).		consensus document).
Saka et al (2009)	UK	to model the long-term (10 years) cost-effectiveness of stroke units (SU) care followed by early supported discharge (ESD)	SUs in the coverage area of the South London Stroke Register, UK	cost-effectiveness modeling. Incremental cost-effectiveness ratios (ICERs) were calculated as cost per QALY to assess the cost-effectiveness of the different strategies.	incident ischemic stroke cases (N=844) observed between 2001 and 2006	SU care without ESD and general medical ward care without ESD	SU care followed by ESD	The main outcome for the model was the combination of death and activities of daily living score as measured by the Barthel Index (BI). BI index scores were expressed in health-related quality-of-life values to calculate the quality-adjusted life-years (QALYs) gained. Costs were analyzed from a societal perspective, not including the transportation costs for outpatients	Using the cost-effectiveness threshold of £30000, as commonly used in the UK, SU care followed by ESD is the cost-effective strategy compared with the other 2 options. The incremental cost-effectiveness ratio of SU care followed by ESD is £10661 compared with the general medical ward without ESD care and £17721 compared with the SU without ESD.	n/a	The ESD strategy analyzed is a specific ESD strategy, which was used by the clinical trial from which the data were drawn. Different stroke care institutions could be using different strategies with different patterns of resource use involved, which could in the end alter the overall effects and the costs. The model did not account for recurrent strokes; therefore, the inherent

Reference	Country	Study objective	Setting	Study design	Participants	Comparison groups	Intervention	Outcomes measured	Results Relative effect (95%CI)	Quality of the evidence	Comments
								to the point of care.			assumption was that the recurrence rates for either of the treatment options were the same. The cost savings that can be generated by the reduction in the average hospital length of stay is partly offset by the increase in the ESD rehabilitation costs. However, the increase in costs remains within reasonable limits when compared with the increase in effectiveness.

Note: GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect. Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate. Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. Very low quality: We are very uncertain about the estimate.