Healthcare Improvement Scotland | SHTG Advice on health technologies

SHTG Recommendations 01-21
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In response to enquiry from the Scottish Antimicrobial Prescribing Group and the British Society of Antimicrobial Chemotherapy

Outpatient parenteral antimicrobial therapy (OPAT)

Recommendations for NHSScotland

Outpatient parenteral antimicrobial therapy (OPAT) services should be offered to clinically appropriate patients with serious infections who do not require hospitalisation beyond their need for antimicrobial therapy.

NHSScotland Boards should aim to offer a flexible OPAT service with multiple care pathways designed to meet individual patient needs within the context of local resources and geography. Alternative care pathways include outpatient clinics, nurse visits to patients' homes, or patient or carer self-administration at home.

All OPAT services should ensure clear, ongoing communication with patients and their carers throughout their care. This will ensure that any concerns and risks associated with home-based OPAT are managed as part of the service.

NHSScotland is required to consider the Scottish Health Technologies Group (SHTG) recommendations.

What were we asked to look at?

We were asked by the Scottish Antimicrobial Prescribing Group (SAPG) and the British Society of Antimicrobial Chemotherapy (BSAC) to provide advice on the use of outpatient parenteral antimicrobial therapy (OPAT) in Scotland. In addition to a review of the published evidence comparing OPAT with inpatient parenteral antimicrobial therapy, we were also asked to compare different models of care for delivery of OPAT services. In particular, we were asked to evaluate the cost effectiveness of OPAT service delivery models.

Why is this important?

An estimated one in three hospital patients in the UK will receive an antimicrobial medication, often intravenously, to treat a serious infection. Intravenous antimicrobial therapy was once considered a barrier to hospital discharge, but patients can now complete their antimicrobial therapy as part of an OPAT service. Delivery of OPAT in the outpatient or community setting has many potential benefits including reduced risk of hospital-acquired infections, resource savings through reduced bed use, increased patient satisfaction, and care closer to home. A shift towards increased intravenous antimicrobial provision closer to the patients' home also reduces the number of patients visiting or staying in hospitals during the current COVID-19 pandemic.

What was our approach?

We produced SHTG Recommendations based on a literature review and *de novo* cost analyses for NHSScotland. The literature review covered evidence on clinical effectiveness, OPAT models of care, cost effectiveness, safety, and patient experiences. The economic modelling explored the cost effectiveness of different OPAT delivery models. Information on our SHTG Recommendations product can be found here.

What next?

The SHTG Recommendations will be circulated to BSAC and the Scottish Government (including unscheduled care, healthcare associated infection, and antimicrobial stewardship policy teams), who will use the recommendations to support future planning of OPAT services across Scotland.

Key points

- The published evidence relating to OPAT clinical effectiveness, safety and different models of care is limited to three systematic reviews of mainly single-arm case series and cohort studies. Selection bias was inherent in most primary studies as patients were allocated to OPAT, inpatient care, or specific OPAT models based on clinical criteria and therefore likely differed in infection type, severity of infection, co-morbidities, and other characteristics.
- Evidence on the effectiveness and safety of OPAT services should be interpreted with caution due to the likelihood of differences in underlying patient characteristics between OPAT and inpatient care.

Effectiveness and safety of OPAT compared with inpatient care

- A systematic review (128 studies total; 21 comparative) comparing adult OPAT with inpatient care found no differences in duration of therapy (6/9 studies) and inconclusive results for infection cure and improvement rates (six studies).
- In another systematic review (19 studies) comparing OPAT at home with inpatient care in children, there were no significant differences in treatment failure rate. Seven out of 15 studies reported significantly longer treatment duration in children treated with OPAT at home. This may be due to less frequent reviews of infection status in children at home. Results for readmission to hospital were not reported (two studies) or not statistically significant (four studies).
- A third systematic review of different age groups (44 studies total; two comparative) reported mean hospital readmission rates with OPAT as 6.4% in mixed age populations (25 studies), 5.2% in adults aged >60 (five studies), and 8.7% in children aged <18 (four studies). No data on inpatients were presented due to the lack of comparative studies.
- In the systematic review comparing adult OPAT with inpatient care, there were no differences in patient mortality in five out of six studies. There were no differences in drug-related side-effects in six studies, OPAT had fewer drug-related side-effects in two studies, and data were not extractable from two studies. There was a suggestion of an increased number of venous access line-related complications in OPAT patients in two studies, and two studies found no difference in this outcome.
- Few adverse events (range 0 to 2) were reported for either OPAT or inpatient care in the ten studies reporting this outcome in the systematic review of home-based OPAT in children.
- The review of OPAT in different age groups reported:
    - Mean vascular access device-related complication rates of 3.9% in mixed age groups (21 studies), 18.5% in older adults (>60 years; three studies) and 14.6% in children (<18 years; five studies).

- Mean drug-related adverse event rates were 5.4% in mixed age groups (23 studies), 5.5% in older adults (four studies), and 9.8% in children (five studies).
- The mean mortality rate was 0.5% in mixed age groups (12 studies) and 2.1% in older adults (three studies). No studies reported mortality in children.
- Data on safety outcomes were not available for inpatients due to the lack of comparative studies.

Comparing OPAT models of care

- In a systematic review (128 studies) comparing four different models of adult OPAT care with inpatient care:
  - Single-arm studies reported similar mean infection cure and improvement rates across different OPAT models of care: self-administration 91.3%, specialist nurse administered 90.6%, general nurse administered 90.0%, and outpatient clinic attendance 88.3%.
  - For each OPAT model compared with inpatient care, there were a maximum of four studies for each outcome.
  - No differences in duration of treatment were found for any model of OPAT compared with inpatient care.

De novo cost minimisation analysis

- An SHTG *de novo* cost-minimisation analysis found that all evaluated OPAT service delivery models were consistently less costly compared with inpatient care.
  - Cost models were developed for the indications that represent the majority of infections treated via OPAT in the UK: skin and soft tissue, complex urinary tract, bone and joint, diabetic foot, bronchiectasis, and intra-abdominal infections.
  - The extent of cost reductions associated with OPAT relative to inpatient care was sensitive to the underlying infection and OPAT model of care.
  - Across the different infections modelled, the cost of OPAT (excluding oral therapies) ranged from 23% to 51% of the cost of an equivalent inpatient stay for patients with short-term infections and ranged from 22% to 56% for longer-term infections.
  - Self-administration (bolus IV) was associated with the lowest costs per OPAT treatment episode across all infection types, and nurse home visits the highest cost.
  - As a component of OPAT services, supervised oral therapies were associated with substantial cost reductions for the treatment of orthopaedic (bone and joint) and diabetic foot infections.

Patient and social aspects

- Two qualitative studies from England (n=32; n=12) and one from Scotland (n=20) explored patient experiences and views on OPAT.
    - Participants in all three studies were adults, although one study was based on parents of children who had received OPAT.
    - The main perceived benefits of OPAT, regardless of model of care, were avoiding unnecessary hospital admissions, enjoying the comforts and security of home, and reduced disruptions to daily life (including work).
    - Clear communication between the OPAT team and patients, and between the hospital and community healthcare, was highlighted as being important to patients.
    - Concerns described by patients related to travel, the impact of OPAT on family and friends, a perceived risk of hospital-acquired infections, fears about returning to daily life and line-related complications, perceived premature transition to oral antimicrobials, and cleanliness of the home environment for home-based care.
    - In an analysis of patients in north-east Scotland, the main reasons for not self-administering OPAT were a lack of awareness it was a treatment option, a perception that hospital staff were the most appropriate people to deliver antimicrobial therapy, and anxiety about potential complications with self-administration.
- A cross-sectional study in NHS Lothian (n=4,944 in univariate analysis; n=4,902 in multivariate analysis) identified significant inequities in access to OPAT services, with people from the most deprived socioeconomic group and women being significantly less likely to be referred for OPAT.

SHTG Council considerations

- The Council recognised that the range of published literature illustrates how each OPAT model of care has advantages and disadvantages, and that a flexible service - offering more than one model of care - should ideally be available to ensure that relative advantages are attained according to differing patient needs.
- The Council acknowledged that increased equitable access across NHSScotland to OPAT services would progress the national aim to provide care closer to home, support patient preference to avoid hospital, and reduce pressure on hospital bed capacity. Equitable access should take into account socioeconomic groups and gender.
- The Council discussed the BSAC good practice recommendations for OPAT in adults and children in the UK. The Council agreed that the BSAC recommendations should be adhered to within OPAT services in Scotland. Of particular note within the BSAC good practice recommendations, the Council noted the importance of providing 24-hour access to OPAT

support. Information on how to access and provide this support should be communicated in writing to patients and service providers respectively.

- The Council debated the challenges around funding of OPAT services. Whilst it was recognised that OPAT generates efficiency savings for NHSScotland, an inability to reallocate resources between care providers (for example, between inpatient and outpatient services, or between primary and secondary care) means that additional funding will be required to initiate equitable OPAT provision across Scotland. Additional funding requirements are largely driven by an increased workforce requirement to deliver OPAT, for example specialist pharmacist input.
- The ongoing COVID-19 pandemic was referenced during the Council's deliberations. A shift towards increased intravenous antimicrobial provision closer to the patients' home reduces the number of patients visiting or staying in hospitals. An increase in the use of telehealth during the pandemic was also suggested as a means of providing remote support to patients receiving OPAT.
- The Council referenced the importance of local context, and that the provision of OPAT should take into account local delivery constraints. The Council were clear that this should not affect access to OPAT services *per se*, but that it may impact upon the most appropriate model of care for individual patients.
- The Council discussed how OPAT is an important part of the national antimicrobial stewardship strategy. OPAT could reduce the risk of nosocomial infection, minimise unnecessary antibiotic use, and ensure patients are involved in decision making around antibiotic use.
- The importance of ongoing data collection and analysis was emphasised by the Council, in order to inform future service decisions. It was proposed that all OPAT services in NHSScotland should be encouraged to participate in the BSAC OPAT initiative to support service development and quality improvement.

Contents

Literature search

A systematic search of the secondary literature was carried out on 9 and 10 July 2020 to identify systematic reviews, health technology assessments and other evidence-based reports. Medline, Medline in process, Embase, Cinahl, and Web of Science databases were searched for systematic reviews and meta-analyses.

At the same time, a systematic search of the literature was carried out to identify qualitative studies on patient experiences and views. The Medline, Medline in process, and PsychInfo databases were searched.

A systematic search of the literature between 3 and 7 August 2020 identified economic analyses. The NHS Economic Evaluations Database, Medline, Medline in process, Embase, Epistimonikos, Pubmed, and HMIC databases were searched.

Key websites were searched for guidelines, policy documents, clinical summaries, economic studies, and patient experiences.

Results from all searches were limited to English language. Concepts used in all searches include: outpatient parenteral antibiotic therapy, ambulatory, patient/carer administered, parenteral, intravenous, IV. A full list of resources searched and terms used are available on request.

Introduction

An estimated one in three hospitalised patients in the UK will receive antimicrobial therapy on any given day.[1] In 2018, intravenous (IV) antimicrobials accounted for 30% of prescribing in acute care.[1] Use of IV antimicrobial therapy is generally reserved for the most serious and complex infections, and is often seen as a barrier to hospital discharge.[2] Patients who are clinically stable in terms of their infection and do not require hospitalisation for other reasons, could be discharged to an outpatient parenteral antimicrobial therapy (OPAT) service to complete their IV antimicrobial treatment.[3, 4]

OPAT refers to the administration of parenteral (normally IV) antimicrobial therapy in an ambulatory setting, such as an outpatient clinic or a patient's home.[2] IV treatment of infections at home or in an outpatient setting has many potential benefits including a reduced risk of hospital-acquired infections, NHS resource savings through reduced bed-use, and increased patient satisfaction.[5] First described over 40 years ago in the United States of America, OPAT services first appeared in the UK around 20 years ago.[6] In the last decade these services have begun expanding in an *ad hoc* manner, with a 2013 British Society of Antimicrobial Chemotherapy (BSAC) survey finding 68% of UK centres offering some form of OPAT service.[4] Owing to this *ad hoc* expansion of services, considerable variation exists in the extent of OPAT service provision (and models of care within these services) in the UK.

Research questions

In order to facilitate the provision of recommendations for Scotland, the evidence review sought to address three research questions:

- Is OPAT clinically effective, cost effective, and safe, compared with inpatient parenteral antimicrobial therapy?
- What is the most clinically and cost effective model of care for delivery of OPAT services?
- What are patients' experiences and preferences in relation to OPAT services (compared with inpatient treatment and comparing between models of care)?

Health technology description

There are a variety of models of care used in delivering OPAT services. All of these models aim to deliver OPAT through an outpatient clinic or in a community setting, such as the patient's home. Other common features of OPAT services include clinical or nursing staff with responsibility for delivering the service, criteria for selection of appropriate patients, and monitoring arrangements for patients during their treatment.[2, 6]

Patients can be referred to OPAT services from the accident and emergency department, or from primary care. It is also common for patients to begin IV antimicrobial therapy as an inpatient and continue treatment through an OPAT service after discharge from hospital.[7]

Antimicrobials used in OPAT can be administered as an IV infusion or IV bolus and a range of delivery devices are available.[2] The choice of device and mode of delivery depends on local healthcare resources and expertise, compatibility and stability of the antimicrobial agent, and national or local guidelines.[6] The device selected also depends on the duration of therapy and whether the drug will be administered by a healthcare professional or by the patient or carer. The choice of antimicrobial is influenced by the antimicrobial stewardship agenda, balanced against a preference for single daily dose antimicrobials in the OPAT setting.[6, 8]

Although patients within an OPAT service predominantly receive IV antimicrobials, the goal is for all patients to transition to appropriate oral antimicrobial therapies.[2] Some patients continue to be monitored through an OPAT service after transitioning to oral therapy and increasingly OPAT services are being used to monitor patients on complex oral antimicrobial regimens.[9]

OPAT in Scotland

In total there are nine OPAT services in NHSScotland within the following NHSScotland health boards: NHS Lothian, NHS Greater Glasgow and Clyde, NHS Lanarkshire, NHS Tayside, NHS Highland, NHS Forth Valley, NHS Fife, NHS Grampian, and NHS Dumfries and Galloway. NHS Borders, NHS Ayrshire and Arran, and the Scottish island health boards all deliver OPAT on an *ad hoc* basis. There are currently no dedicated paediatric OPAT services in NHSScotland and there is considerable geographical variation in access and uptake of adult services (Dr A Seaton, Consultant in Infectious

Diseases and General Medicine, NHS Greater Glasgow and Clyde. Personal communication, 21 October 2020).

Table 1 provides an overview of the models of care currently available in Scottish OPAT services. The most common OPAT model of care is an outpatient OPAT clinic in the majority of Scottish NHS Boards. In NHS Highland the most common model is a community nurse attending the patient's home. Eight out of nine OPAT services have an option for patients to self-administer at home. Only two services – NHS Lothian and NHS Dumfries and Galloway – offer the option of a specialist OPAT nurse home visit.

Table 1: overview of OPAT service delivery models from an email survey in NHSScotland in 2019-2020 (Dr A Seaton, Consultant in Infectious Diseases and General Medicine, NHS Greater Glasgow and Clyde. Personal communication, 4 December 2020)

Board	OPAT clinic	MAU	Self-administered	OPAT nurse at home	Community nurse at home	Community hospital	HCITH link
Dumfries & Galloway							
Fife							
Forth Valley							
GGC							
Grampian							
Highland							
Lanarkshire							
Lothian							
Tayside							

MAU = medical assessment unit; HCITH = healthcare in the home; GGC = Greater Glasgow and Clyde

	Most frequent		Moderate frequency		Least frequent		Not available

Epidemiology

In 2019 there were a total of 1,211 episodes* of adult OPAT care reported to the BSAC national outcomes registry from five services in NHSScotland).[7] Data on the most commonly treated infection types in OPAT services in Scotland in 2019 are presented in table 2.

Table 2: data on commonly treated categories of infection in Scottish adult OPAT services in 2019, as extracted from the BSAC national outcomes registry.[7]

Infection type	n episodes	% of all infections treated	n treatment days saved	Weighted mean duration of treatment (days)
Skin and soft tissue (including cellulitis)	572	47.2%	2,327	4.1
Osteomyelitis / orthopaedic (bone and joint)	217	17.9%	6,436	29.7
Urinary tract	55	4.5%	445	8.1
Bronchiectasis or respiratory tract	46	3.8%	523	11.4
Diabetic foot	38	3.1%	781	20.6
Gastrointestinal	31	2.6%	661	21.3

A retrospective cohort study described the first 10 years of the OPAT service in NHS Greater Glasgow and Clyde (2001-2010).[10] During this 10-year period, 2,233 patients received 2,638 episodes of OPAT care, which equates to approximately 220 patients per year if distributed equally across the years. Fifty-eight percent of patients were male. Patients had a median age of 51.1 years, with a range – 13.1 to 94.9 years – encompassing the young and the very elderly. Treatment duration per patient ranged from <1 day to 328 days, with a median of six days (inter-quartile range (IQR) three to 20 days). Over the 10 years, 76.7% of patients were treated in an OPAT outpatient clinic, 18.7% self-administered, and 3.9% were treated at home by a healthcare professional. The proportion of patients who self-administered IV antimicrobials, or had a carer administer them, increased from 8.3% in 2001 to 24.3% in 2010 (X^2 test for trend = 48.49, p<0.0001).

* Episodes of care or infection in OPAT services are not equivalent to number of patients as some patients will experience multiple infections or episodes of care within a single year.

Clinical effectiveness: OPAT versus inpatient parenteral antimicrobial therapy

Three systematic reviews of mainly observational, single-arm studies assessed the efficacy of OPAT in patients with serious bacterial infections.[5, 11, 12] None of the systematic reviews included a meta-analysis due to high levels of between-study heterogeneity in the clinical characteristics of participants and study methodologies.

One systematic review assessed the efficacy and safety of OPAT compared with inpatient antimicrobial therapy as part of a wider piece of work exploring OPAT service delivery models in NHS England.[11] The review included studies of any design (except case reports) that assessed any antibiotic, any IV drug delivery system, in any adult patient population. Studies were assessed for risk of bias by the systematic review authors using the Cochrane risk of bias tool for randomised controlled trials (RCTs), the Newcastle-Ottawa scale for appraising non-randomised studies, or a tool developed by the review authors. Any case series that were not suitable for assessment using one of these tools were not formally appraised.

One hundred and twenty-eight studies, reporting over 60,000 episodes of OPAT care were included in the systematic review. The majority (67%) of studies were observational, although 14 trials and a literature review were also included. Three trials had a low risk of bias, one a high risk of bias, and 10 an unclear risk of bias. Five case-control studies and four cohort studies had low potential for bias. The remaining studies were all case series and were not formally appraised.

Fifty-three studies (41%) were conducted in Europe, including 33 in the UK. Sample size varied from six to 11,427 patients or episodes of care, with a mean of 476 and a median of 100. Almost two-thirds (63%) of studies had less than 150 participants. The most common infections addressed in the primary studies were osteomyelitis (53%), endocarditis (41%), skin and soft tissue infections (32%), cellulitis (25%), and septic arthritis (23%).

Of the 89 studies evaluating the clinical effectiveness of OPAT, only 21 included a comparator, normally inpatient care. Table 3 presents the findings of this systematic review based on comparative studies. Review results were reported as no difference, superior, inferior, or inconclusive for each outcome (see appendix 2 table A for a summary of results from individual studies). Eight out of nine studies assessing duration of treatment found no difference between OPAT and inpatient therapy. Evidence on the effects of OPAT on infection cure and improvement was inconclusive: two studies found no difference between groups; two studies reported superior cure rates in OPAT services; one study found OPAT had inferior cure rates compared with inpatient care; and one study found a non-significant difference favouring the OPAT group. In non-comparative studies, cure and improvement rates for OPAT ranged from 61.1% to 100% (mean 89.6%, median 92.5%).

Table 3: summary of difference in effect for clinical and safety outcomes reported in a systematic review comparing OPAT with inpatient treatment in adults[11]

Outcome	Total n studies (n patients)	Effect: OPAT results relative to inpatient care
Duration of treatment	9 (11,523)	No difference (8/9 studies) Duration of treatment in one study was not clearly reported in the systematic review.
Rate of cure and improvement	6 (639)	Inconclusive Two studies found no difference. Two studies found OPAT superior. One study found OPAT inferior and one study found a non-significant difference favouring the OPAT group.
Hospital readmission	8 (c11,801)*	Inconclusive Three studies found no difference. Two studies found OPAT superior. One study was incorrectly referenced and could not be checked.
Mortality	6 (11,259)	No difference (5/6 studies) The outlying study found OPAT inferior to inpatient care.
Drug-related side effects	10 (c898) *	No difference (6/10 studies) Two studies found OPAT superior. One study was incorrectly referenced and could not be checked. Drug-related side-effects were not clearly reported for one study in the systematic review.
Venous access complications	4 (221)	Inconclusive Two studies found OPAT inferior. Two studies found no difference.

**Some studies did not report exact numbers of patients in historical comparator groups, hence these figures are approximations.*

The second systematic review assessed the efficacy of home-based OPAT compared with hospital-based parenteral antimicrobial therapy in children aged 16 or younger.[5] The systematic review authors used GRADE criteria to assess the quality and risk of bias in included studies (n=19). All included studies were judged to have very low, low, or moderate risk of bias. Evidence quality was considered to be low due to the lack of randomised studies (only one RCT included). It was not possible to exclude the risk of selection bias in most studies, as sicker children were more likely to be treated in hospital. Eight studies included both paediatric and adult patients, and it is unclear if data specific to children were extracted from these studies. The infections treated within studies fell into

three categories: acute infections in previously healthy children (six studies), infections in children with low-risk, chemotherapy-induced febrile neutropenia (two studies), and respiratory infections in children with cystic fibrosis (12 studies).

Efficacy results from the 19 studies included in the systematic review are presented in appendix 2 table B. Five studies reported on treatment failure: three for acute infections and two for low-risk febrile neutropenia. No significant differences in treatment failure between home and hospital treatment were found. Two studies in children with low-risk febrile neutropenia reported no significant difference in mean number of days until remission of fever. Duration of treatment was reported in 15 studies: seven in children with cystic fibrosis, two in children with febrile neutropenia, and six in children with acute infections. Five out of seven studies in children with cystic fibrosis reported a longer treatment duration in children treated with OPAT at home compared with inpatient treatment. Longer treatment duration at home compared with inpatient care was also reported in one study in children with febrile neutropenia and one study in children with acute infections. In the six studies reporting readmissions to hospital after completion of antimicrobial therapy, statistical comparisons were either not reported (n=2) or not significant (n=4). Similarly, results for disease-related complications were either not reported (n=3) or not significant (n=1).

The third systematic review evaluated OPAT and hospital-at-home in three age groups: a mixed age group, adults over the age of 60, and children <18 years.[12] Only observational studies were included. There were forty-four studies included in the systematic review: 42 single-arm case series and two comparative studies, both of which related to hospital-at-home. The systematic review authors used the Joanna Briggs Institute appraisal tools to assess risk of bias. Of the case series, seven had very low risk of bias, 31 had moderate risk of bias, and four had high risk of bias. Twenty-six case series focused on OPAT in mixed age patients, five on OPAT in older patients, and five on OPAT in children. Infection type was only described for the 26 studies on mixed age populations. These studies assessed OPAT for bone and joint, endovascular, soft tissue, respiratory, central nervous system, and other minor infections. Data on the types of infection in studies on older adults or children were not reported in the systematic review.

Results by age group are summarised in table 4. Studies on OPAT in mixed age populations (n=26) had a sample size between 56 and 4,005 patients. All studies were single-arm case series; four were from the UK, including one from Scotland. Fourteen studies reported a cure or treatment success rate greater than 80% with OPAT. Hospital readmission rates ranged from 1.0% to 14.3%.

Four studies in older adults (age >60) had sample sizes ranging from 17 to 176. These studies reported hospital readmission rates ranging from 2.6% to 14.2%. This group recorded higher hospital readmission rates than the general OPAT population.

In the five studies on OPAT in children the cure and improvement rate was generally greater than 88%. Sample size in studies on children ranged from 98 to 229. Hospital readmission rates among children treated with OPAT ranged from 3.8% to 26.0%.

Table 4: OPAT effectiveness and safety outcomes by patient age group in a systematic review of observational studies[12]

Outcome		OPAT-mixed ages**	OPAT-elderly (age >60)	OPAT-children (age <18)
Hospital readmission rate	n studies (n patients)	25 (c12,487)	4 (792)	5 (840)
	Range	1.0% to 14.3%	2.6% to 14.2%	3.8% to 26.0%
	Geometric mean*	6.4%	5.2%	8.7%
Mortality	n studies (n patients)	12 (c9,830)	3 (587)	-
	Range	0% to 1.4%	0% to 27.5%	-
	Geometric mean*	0.5%	2.1%	-
Vascular access device (VAD) - related adverse events	n studies (n patients)	21 (c11,619)	3 (701)	5 (840)
	Range	0% to 25.0%	15.0% to 22.4%	8.1% to 29.0%
	Geometric mean*	3.9%	18.5%	14.6%
Drug-related adverse events	n studies (n patients)	23 (c13,271)	4 (877)	5 (840)
	Range	0.3% to 30.2%	1.1% to 22.4%	0% to 29.0%
	Geometric mean*	5.4%	5.5%	9.8%

**Geometric mean indicates where calculations have been performed on a logarithmic scale due to skewed data and small sample sizes.*

***Two studies did not report number of patients, therefore some patient numbers are approximations.*

Safety: OPAT versus inpatient parenteral antimicrobial therapy

The same three systematic reviews that evaluated the clinical effectiveness of OPAT compared with inpatient therapy, reported safety outcomes for this comparison.[5, 11, 12]

There were 109 studies reporting safety outcomes in the systematic review on OPAT in adults; 24 of these studies included an inpatient comparator.[11] The most commonly reported adverse events in primary studies were rash, fever, nausea/vomiting, diarrhoea, allergic reaction or anaphylaxis, phlebitis, leucopenia, and line complications (including line infection, occlusion, breakage, or

dislodgement).[4] Five out of six studies reporting patient mortality found no difference between OPAT and inpatient treatment (table 3). One study found mortality to be higher in OPAT compared with inpatient care. Six out of ten studies reporting drug-related side-effects found no difference between OPAT and inpatient therapy. Two studies found drug-related side-effects were lower in OPAT compared with inpatient care. The evidence on venous access line-related complications was inconclusive. Two studies found OPAT to have higher rates of line-related complications, while two studies found no differences between OPAT and inpatient care. These studies may not have been comparing like-with-like as OPAT patients are more likely to have central venous lines which are associated with a higher line-related complication rate.

Results for safety outcomes in the 19 studies included in the systematic review on OPAT services in children are presented in appendix 2 table C.[5] Few adverse events (range 0 to 2) were reported in the ten studies evaluating this outcome. No mortality was reported in any of the included studies.

The systematic review that compared OPAT in three different age groups (mixed ages, adults >60, and children <18) could not compare safety outcomes between OPAT and inpatient care due to a lack of comparative studies.[12] This review reported vascular access device (VAD) adverse events, drug-related adverse events and mortality for OPAT only (table 4). In the mixed age population, VAD-related complications affected between 0% and 25% of patients receiving OPAT (21 studies), in older adults the range was 15.0% to 22.4% (three studies), and in children it was 8.1% to 29.0% (five studies). Adverse drug reaction rates ranged from 0.3% to 30.2% in the mixed age population (23 studies), 1.1% to 22.4% in older adults (four studies) and 0% to 29.0% in children (three studies). Mortality rates ranged from 0% to 1.4% in mixed age populations (12 studies), and 0% to 27.5% in adults aged over 60 (three studies). No studies reported mortality in children.

Two studies on OPAT in older adults compared two or more older age groups. One study compared safety outcomes in adults aged >60 and adults aged <60 years. The adjusted mean rates of VAD-related complications were similar in the two groups (22.4% and 26.6% respectively). The adjusted mean rate of drug-related adverse events was higher in adults aged >60 (22.4% versus 14.5%). In the second study, patients were divided into three age groups: >80 years, between 65 and 80, and <65 years. Adjusted mean rates of VAD-related complications in these groups were 15.8%, 17.6% and 20.2%, respectively, with 3-4% of patients requiring readmission to hospital as a consequence of VAD-related adverse events.

OPAT models of care

This section reviews the published evidence comparing different models of care for the delivery of OPAT services in the UK. Models of care for OPAT have been defined according to the following:

- Setting – hospital outpatient or ambulatory care clinic, community clinic, or patients' homes
- Who administers the IV antimicrobials – a healthcare professional in a clinic, a specialist (OPAT) nurse at home, a district or community nurse at home, or self-administration by patients or carers at home

Most OPAT services offer a combination of models within one service, for example offering patients attendance at an outpatient clinic or self-administration at home.[3] In practice, patients may transition from one model of OPAT care to another as their condition changes, for example going from daily clinic visits to self-administration at home as they transition from IV to oral antimicrobials.

OPAT model-specific considerations

Outpatient or ambulatory care clinics

OPAT patients attend a hospital-based clinic, normally an outpatient or day clinic, on a daily basis and IV antimicrobials are administered by a healthcare practitioner.[3] The main consideration specific to this OPAT model of care is daily patient travel to the clinic, as some patients may not be fit to travel and there are costs and inconvenience associated with repeated daily journeys to the hospital.[4]

Self- or carer-administered OPAT

Self- or carer-administration of IV antimicrobials in the home setting can be advantageous for patients who require very long or repeated courses of treatment, or patients of working age.[4] This approach may not be suitable for all patients, for example adults with cognitive impairment or patients who prefer to have a nurse administer their medication.

In order for patients or carers to self-administer IV antimicrobials they must first undergo a period of relatively intense training in order to ensure successful self-administration.[13] This has resource implications in terms of nurse time for training and additional equipment, such as infusion pumps, that patients need at home for self-administration. There may be increased risks from unsupervised administration of IV antimicrobials by patients or carers, and non-compliance with treatment. Patients self-administering will normally have a weekly review at an outpatient clinic and 24-hour access to telephone-based help, to mitigate these risks (Mr Mark Gilchrist, Consultant Pharmacist in Infectious Diseases, Imperial College Healthcare NHS Trust. Personal communication, 21 October 2020).

Nurse administered OPAT at home

Either a specialist OPAT nurse or a district/community nurse can administer OPAT in the patient's home.[4] Advantages of the district/community nurse model include the ability to complete other nursing tasks at the same time, such as wound management, and shorter travel times compared with specialist nurses as the district/community nurses are likely to be based locally. District/community nurses may not have specific training on administering IV antimicrobial therapy. The advantage of the specialist OPAT nurse administering treatment is that they are more skilled in IV antimicrobial administration. This becomes a less efficient model of care than the community nurse model if the hospital the nurse covers a large geographical area because more time is lost in travel and the number of patients that can be cared for through OPAT is reduced.

Home-based OPAT models

One study highlighted potential hazards associated with OPAT in the home environment.[14] A qualitative study in the US identified seven hazards affecting home-based OPAT patients: bathing while keeping dressings dry; avoiding pet fur and waste; indoor temperature extremes affecting dressings; household clutter contaminating equipment; indoor food and soil exposure; outdoor work; and travel. These hazards could compromise the integrity of dressings, lead to equipment contamination, and expose the patient to the risk of further infection.

Other considerations when delivering OPAT at home include whether there is a stable home environment (particularly in the case of children), adequate refrigeration for medication storage, and access to a telephone in case of problems.[15]

Home-based OPAT in children

A scoping review identified factors affecting the provision of home-based OPAT services specifically for children and young people.[15] Half the services described in the 19 studies included in the scoping review focused on treating a single type of infection, for example urinary tract infections. Parental compliance and reliability were key factors determining the eligibility of children for OPAT care at home. Parents were trained to administer IV antimicrobials to their child in six studies; in all cases the child had a pre-existing condition. Even when a nurse was responsible for administering the antimicrobial, parents required training on how to identify complications, deterioration, and other problems. The degree of support for children undergoing OPAT at home varied from daily phone calls and home visits as needed, to initial daily or twice daily visits, or visits approximately once every 2.9 days, and 24-hour access to professional support.

Effectiveness of OPAT models of care

One of the systematic reviews (n=128) identified for this evidence review reported – in two separate publications – outcomes across different OPAT models of care.[4, 11] Four OPAT models of care were considered: treatment in an outpatient clinic (n=35), self- or carer-administration at home (n=66), general or district nurse administration at home (n=14), and specialist nurse administration at home (n=44). Twenty-two studies did not indicate the type of OPAT model used or stated only that it was home-based. Only 21 studies compared one or more OPAT models with inpatient care. In all comparisons of specific OPAT models of care with inpatient care, there were small numbers of studies (one to four) contributing to the conclusions for each outcome. In addition, results should be interpreted with caution due to likely selection bias for different models of care. It is likely, for example, that very sick patients would not be offered OPAT and that patients who received a specialist nurse visit at home may be frailer or unable to attend an OPAT clinic for other reasons.

In single-arm studies, the mean cure and improvement rate in OPAT was similar across models of care: self-administration (91.3%), specialist nurse administered (90.6%), general nurse delivered (90.0%), and outpatient clinic attendance (88.3%).[11] Effectiveness and safety results from comparisons of individual models of OPAT care and inpatient therapy are presented in table 5 (see

appendix 2 table A for a summary of the results from individual studies). Evidence was not available for all four OPAT models of care for every outcome.

No difference in duration of treatment was found for any model of OPAT compared with inpatient care. Outpatient clinic attendance appeared to have a lower rate of infection cure and improvement than inpatient treatment (one study). Compared with inpatient care, self-administration at home (one study) and specialist nurse administered OPAT (one of two studies) had higher rates of cure and improvement. OPAT delivered by a district or community nurse had little or no impact on rates of recovery compared with inpatient care (two studies). Compared with inpatient care, specialist nurse-delivered OPAT had fewer hospital admissions (2/4 studies) and outpatient clinic attendance had lower rates of drug-related adverse events (one study).

Table 5: summary of difference in effects on clinical and safety outcomes for specific OPAT models of care compared with inpatient treatment in adults[4]

Outcome	OPAT model of care	n studies reporting effect / n studies reporting outcome (total n patients)	Effect: OPAT results relative to inpatient care
Duration of treatment	Outpatient clinic	1/1 (84)	No difference
	Self-administered	3/3 (143)	No difference
	District or community nurse	2/2 (243)	No difference
	Specialist OPAT nurse	2/3 (11,085)	No difference Two studies showed no difference. One study was not clearly reported in the systematic review.
Rate of cure or improvement	Outpatient clinic	1/1 (84)	Inferior
	Self-administered	1/1 (111)	Superior
	District or community nurse	2/2 (243)	No difference
	Specialist OPAT nurse	1/2 (201)	Superior

			One study found OPAT superior. One study found a non-significant difference favouring the OPAT group.
Hospital admissions	Self-administered	2/2 (231)	No difference
	District or community nurse	2/2 (243)	Inferior
	Specialist OPAT nurse	2/4 (c11,327)*	Superior Two studies found OPAT superior. One study found no difference. One study was incorrectly referenced and could not be checked.
Mortality	Outpatient clinic	1/1 (84)	Inferior
	Self-administered	2/2 (142)	No difference
	District or community nurse	1/1 (49)	No difference
	Specialist OPAT nurse	2/2 (10,984)	No difference
Drug-related side effects	Outpatient clinic	1/1 (84)	Superior
	Self-administered	4/4 (223)	No difference
	District or community nurse	1/1 (49)	No difference
	Specialist OPAT nurse	4 (c543)*	Inconclusive One study OPAT superior. One study found no difference. One study was incorrectly referenced and could not be checked. Drug-related side-effects were not clearly reported for one study in the systematic review.
Venous access complications	Self-administered	2/3 (172)	Inferior Two studies found OPAT inferior. One study found no difference.

	District or community nurse	1/1 (49)	No difference

**Some studies did not report exact numbers of patients in historical comparator groups, hence these figures are approximations.*

One other systematic review briefly references comparison of OPAT models of care (one primary study, 2,039 episodes of care).[12] In comparisons of OPAT administered by healthcare staff versus patient self-administration, there were no statistically significant differences in VAD-related complication rates (0.5% versus 1.0%) or drug-related adverse events (12.2% versus 12.5%).

BSAC good practice recommendations

In 2019, BSAC published updated good practice recommendations for adult and paediatric OPAT services in the UK.[6] Based on a literature review (current up to August 2018) and an extensive four week consultation with experts, the good practice recommendations are intended to act as a set of quality indicators for OPAT service evaluation and quality improvement. Recommendations/ indicators are presented for five key areas: OPAT team and service structure; patient selection; antimicrobial management and drug delivery; monitoring the patient during OPAT; and outcome monitoring and clinical governance. The full list of recommendations is presented in appendix 3.

Cost effectiveness

Published evidence

One study was identified that compared the cost-effectiveness of different OPAT service delivery models.[4] Three other studies compared costs for OPAT and inpatient stay.[16-18]

The most relevant cost-effectiveness evidence for OPAT in the Scottish context comes from one study that presented two cost-utility analyses for the evaluation and comparison of OPAT service delivery models for short-term (up to 7 days) and longer-term infections.[4] The study used data from hospital records in England and the published literature to estimate cost per quality-adjusted life year (QALY) gained from the perspective the NHS. A discrete event simulation (DES) model was used to model patient pathways over a 12-month period comparing hospital outpatient daily visits, nurse (general or specialist) home visits, and self-administration (only for infections requiring longer-term treatment). In the model, patients were exposed to the probability of experiencing any of three adverse events - anaphylactic shock, *Clostridium difficile* infection (CDI) or intravenous line infection - and subsequently the probability of death. Within the model, patients attending daily hospital outpatient clinics were assumed to have the greatest risk of CDI and self-administering patients were assumed to have the lowest risk. The model further assumed that patients visiting an outpatient clinic daily would only have one review with an infectious disease specialist. Patients who are visited by a nurse or self-administer were assumed to have an appointment with an infectious disease

specialist every two weeks (for longer-term infections) and one final assessment at discharge. The probability of relapse was not accounted for in the model as it was found to be similar across the different OPAT service delivery models. The measure of effectiveness in the study was days of treatment as observed in the hospital records for each of the OPAT service delivery models.

Results from the analysis of short-term infections showed that the specialist nurse home visit OPAT model was more cost-effective than the outpatient clinic daily visit model. In the longer-term treatment model, the analysis found that self-administration was the most cost-effective OPAT model. In a fully incremental analysis, the hospital outpatient clinic daily visits model was dominated (more expensive and less effective) by the specialist nurse home visits model.

The study's cost-effectiveness results are driven by differences in rates of adverse events between OPAT models and assumptions about costs. The costs associated with nurse home visit models may be underestimated as the cost of nurse's time travelling to patients' homes does not seem to have been included in the model. In some parts of Scotland nurses may be required to travel long distances, which could have a substantial impact on costs and capacity.

One study presented a cost analysis for the comparison of OPAT with inpatient care.[16] For the purposes of costing OPAT, the study used 10-year (2006-2016) retrospective cost and outcomes data from an OPAT unit in Sheffield, England. There were 3,812 episodes of OPAT treatment during this time period and the total cost of the service was £4,824,507. The costs accounted for in the analysis were staff (55%), consumables and equipment - including antimicrobials (14%), and overheads and support (31%). The study found that the cost of OPAT was approximately 15% of the cost of an inpatient stay if all patients were hospitalised in an infectious disease unit (£32,715,992), and 40% if patients were hospitalised in other departments (£11,961,081).

Another study using two years of data (2006-2007) from the same OPAT unit in Sheffield for 334 treatment episodes found the total cost of OPAT for that period to be £612,306, which equated to 41% of equivalent inpatient costs for a patient's in an Infectious Diseases Unit (£1,502,769), 47% of equivalent inpatient costs using national average costs (£1,312,537), and 61% of inpatient costs using minimum inpatient costs for each diagnosis (£1,005,676).[18]

The final study estimated treatment for 151 patients who were hospitalised with methicillin-resistant *Staphylococcus aureus* (MRSA) complicated skin and soft tissue infections in Glasgow.[17] Out of these 151 patients, 37 were discharged from hospital to continue treatment in OPAT. The results showed that for the 37 patients treated in OPAT, costs were £228,651 or approximately 50% of the cost for an equivalent duration inpatient stay (£455,685).

De novo cost-minimisation analysis

SHTG conducted a cost-minimisation analysis comparing models of OPAT delivery/care with inpatient parenteral antimicrobial therapy in the UK. Based on available published clinical effectiveness evidence[4, 5, 12] and clinical expert opinion, assuming equivalence in patient outcomes for OPAT and inpatient stay, as well as for the different models of healthcare delivery in OPAT, was

considered appropriate. The analysis considered three main OPAT models for IV antimicrobial treatment delivery that are generally available in the UK: attending an outpatient clinic on a daily basis, home visits by a specialist OPAT nurse, and self-administration (by bolus IV or elastomeric device). A model incorporating continuous intravenous infusion (CIVI) of antimicrobials via an elastomeric device in an outpatient setting was also considered. The estimated average costs of these models were calculated across six infection categories based on the most prevalent infection diagnoses within the BSAC national outcomes registry[7]: skin and soft tissue infections (SSTI), orthopaedic (bone and joint) infections, diabetic foot infections, complex urinary tract infections (UTI), bronchiectasis, and intra-abdominal infections (see appendix 4 table A for a breakdown of infections included in each category). Additionally, in order to take into account recent developments in outpatient practice, the analysis considered the costs of delivering oral therapies through OPAT for patients with orthopaedic or diabetic foot infections.

Methods

Data

The cost-minimisation analysis used five years of retrospective data relating to 21,632 adult treatment episodes at 44 centres in England, five in Scotland, four in Wales and four in Northern Ireland, that all reported to the BSAC national outcomes registry.[7] Suitable patients received OPAT for one or more of six broadly defined infection categories, which represent approximately 82% of primary OPAT diagnoses (table 6): infections requiring short-term (up to 7 days) antimicrobial treatment (SSTI and complex UTI) or longer-term antimicrobial treatment (orthopaedic infections, diabetic foot infections, bronchiectasis, and intra-abdominal infections).

Table 6: average duration of treatment and total number of treatment episodes in OPAT for six categories of infection

Condition / infection	Average duration (days)	Number of treatment episodes	Source
SSTI	6.4	7,371	NORS 2015-19 (UK)[7]
Complex UTI	7.0	1,896	
Bone and joint	27.8	5,355	
Diabetic foot	28.3	1,797	
Bronchiectasis	11.0	4,096	
Intra-abdominal	22.2	1,117	

SSTI = skin and soft tissue infections; UTI = urinary tract infections; NORS = national outcomes registry system

Healthcare specialists in OPAT

For the purpose of this analysis it was assumed that following referral to OPAT, all patients were assessed by a specialist OPAT nurse prior to hospital discharge. The initial assessment would take approximately one hour and included a physical examination, a range of laboratory tests, insertion of a vascular access device if necessary, and development of a personalised treatment plan. The latter was assumed to require 15 minutes of a pharmacist's time. Depending on the model of care,

patients were assumed to be reviewed daily or once weekly by a specialist OPAT nurse. Patients requiring longer-term treatment (more than seven days) would be assessed weekly at a multi-disciplinary team (MDT) meeting. The majority of patients were assumed to have at least one consultant-led assessment during or prior to discharge from OPAT. The management of skin and soft tissue infections was assumed to be primarily nurse-led, where the need for consultant assessment was rare. Consultant time was factored in to the analysis where patients were treated with dalbavancin. The impact of adding consultant time for all patients in the analysis was explored in the scenario analysis.

Antimicrobials

Antimicrobial medications with a lower frequency of administration compared with hospital inpatient care are most commonly selected for use in OPAT. In the cost-minimisation analysis, the type and distribution of antimicrobial medicines used in OPAT were based on clinical expert opinion and the most prevalent agents used within the BSAC national outcomes registry (appendix 4 table B).

Antimicrobial medicines which require more than once daily administration (piperacillin with tazobactam, flucloxacillin, temocillin, ceftazidine and meropenem) would be primarily self-administered by the patient or their carer. If an antimicrobial is stable to degradation in the outpatient setting, patients may receive the antibiotic as a 24-hour continuous infusion via an elastomeric device, requiring once daily attendance at an outpatient clinic. UK data support Yellow Covered Document compliant continuous infusion of flucloxacillin with citrate-buffered saline via the elastomeric devices INfusorLV® and Accufuser® kept in a carry pouch,[19] and piperacillin with tazobactam in citrate-buffered saline via the elastomeric devices EasypumpV® and FOLFusor®.[20] Ceftriaxone is also used with the latter two devices in the UK, although there is no published evidence for its stability in them. It is assumed that all other antimicrobials are self-administered as IV bolus since there are currently no data to support their continuous 24-hour infusion in the community.[20]

OPAT care pathways

The care pathway for the OPAT outpatient clinic model can be summarised as follows: after an initial assessment, the patient travels daily to their nearest OPAT unit for the duration of their treatment, and at the clinic an OPAT nurse prepares and administers their medication intravenously by bolus IV or an infusion pump. Each clinic visit lasts approximately 40 minutes. Information Service Division (ISD) data suggests that the average distance patients in Scotland travel to their hospital appointment is 11 miles.[21] In some cases, patients with mobility issues are eligible for a patient transport service to and from the OPAT unit by an ambulance.

The nurse home visit model is based on a specialist OPAT nurse (or sometimes a district/community nurse) travelling to the patient's home where they spend approximately 10 minutes preparing the medication and another 30 minutes administering it via bolus IV. In Scotland, before the COVID-19 pandemic, this model of care was less popular given the long distances that nurses sometimes had to travel. In an attempt to keep patients away from hospitals during the pandemic, it has become a

more wide-spread approach in some Scottish health boards (Dr Claire Mackintosh, Clinical Director, Regional Infectious Disease Unit, NHS Lothian. Personal communication, 8 September 2020).

The self-administration model of OPAT care entails the patient (or their carer) administering the medication at home, without the need to travel to hospital or for a nurse to visit on a daily basis. This is particularly advantageous for patients with infections requiring longer-term treatment, patients who require more than once daily infusion, and patients of working age. Prior to commencing antimicrobial self-administration, patients receive on average three training sessions (60 minutes each with a nurse) on how to safely prepare and administer their medication through a peripherally inserted central catheter (PICC) line using a bolus IV. Usually only one training session is required for patient- or carer-administration of pre-prepared medications via an elastomeric home infusion device since it only needs to be connected to the PICC line correctly. For patients referred to OPAT who are allocated an elastomeric device with pre-prepared medications, this lower level of training reduces the time from referral to hospital discharge.

For patients who are self-administering, the patient is discharged from hospital with the necessary consumables (for example a leaflet of instructions, syringes, needles, 70% alcohol wipes, 0.9% sodium chloride ampoules, sharps bin, and vials with medication powder for infusion) and is given a contact number for if there are any problems out of hours - in Scotland this is usually an infectious diseases unit. Due to the relatively high acquisition cost of single-use, disposable elastomeric infusion devices, this option is currently less frequently used compared with bolus IV administration in Scotland. Where an elastomeric pump is used in Scotland, these are primarily commercially pre-filled devices due to safety issues relating to the process of filling empty elastomeric devices outside of an aseptic unit and the associated reduction in shelf-life (approximately 24 hours). It is possible that empty devices could be filled by OPAT staff on the same day as administration - this model of care is referred to the continuous intravenous infusion (CIVI) model and has been considered in the analysis where appropriate.

Patients referred to OPAT with bone and joint infections (diabetic foot or orthopaedic infections) are increasingly considered for suitability for discharge on supervised complex oral therapies as an alternative to 'traditional' OPAT IV therapy.[9] Suitable patients may be commenced directly on supervised oral antimicrobial treatment, for example linezolid or combination oral antimicrobial regimens, which frequently require enhanced monitoring due to potentially serious adverse events.

It has been assumed in the analysis that there is a small probability (6.4%) of a patient being readmitted to hospital during OPAT (any model of care) and remaining in hospital until their treatment is completed.

OPAT costs

OPAT costs considered in the analysis (table 7) included specialist staff time (nurses, doctors and pharmacists), antimicrobial medications, elastomeric infusion devices (empty or commercially pre-filled), consumables, laboratory tests, and the cost of daily travel to and from the OPAT clinic where necessary. The costs of rehospitalisation for patients in OPAT have been included. A daily cost per

patient to account for administration and support costs of using a healthcare service has been assumed in the analysis.[4] Other methods for incorporating overhead costs have been explored in scenario analyses.

Costs were obtained from various sources. These included the Personal and Social Services Research Unit (PSSRU),[22] the British National Formulary (BNF),[23] the drugs and pharmaceutical electronic market information tool (eMIT),[24] NHS National Procurement, the Public Health Scotland (PHS) cost book,[21] and NHS England reference costs[25].

It was assumed that in the absence of OPAT, patients would be hospitalised for the equivalent amount of time to receive treatment as inpatients. Therefore, costs of OPAT and inpatient care were compared from the point of admission to discharge.

Cost of adverse events was not included as it was assumed that OPAT services are similar in safety to hospital inpatient care. Additionally, it was assumed that other patient outcomes, such as treatment success, failure, and relapse, would be similar in OPAT and inpatient care.

Table 7: costs of resources used in OPAT services

Item	Unit cost	Notes	Source
Medical consultant	£109	Per working hour	PSSRU, 2019
Pharmacist band 8a	£67	Per working hour	PSSRU, 2019
Nurse band 6	£47	Per working hour	PSSRU, 2019
Nurse band 5	£38	Per working hour	PSSRU, 2019
Antimicrobial medicine (IV)	Variable*	Condition-specific	BNF, 2020 eMIT, 2020
Antimicrobial medicine (oral)	Variable*	Condition-specific	BNF, 2020 eMIT, 2020
Laboratory tests	£8	UE, LFT, CRP and FBC	ISD Cost book, 2020
Laboratory tests (specialist)	£47	Teicoplanin levels	Expert
Consumables - PICC line	£36	Per patient	NHS National Procurement
Consumables - butterfly needle	£1	Per administration	NHS National Procurement
Consumables (other)	£1.65	Single use: apron, needles, syringe, pre-injection swab	NHS National Procurement
Elastomeric device (empty)	£31	Based on equal market share of two devices (single use)	NHS National Procurement
Elastomeric device (commercially pre-filled): piperacillin with tazobactam; flucloxacillin	£90	Per administration	Expert

Elastomeric device (commercially pre-filled): ceftriaxone	£45	Per administration	Expert
Buffered saline	£2	Per administration	Expert
Nurse travel	£11	Per journey - based on average travel of 11 miles	PHS cost book, 2020
Patient transport service	£42	Per journey - based on average travel of 11 miles	PHS cost book, 2020
General cost of using healthcare services	£13	Per patient per day (inflated to 2019 prices using the NHS cost inflation index)	Minton, 2017[4]

**See appendix 4 table C for costs of IV antimicrobials and appendix 4 table D for oral antimicrobial costs*
UE = urea and electrolytes; LFT = liver function test; CRP = c-reactive protein test; FBC = full blood count; PSSRU = Personal Social Services Research Unit[22]; BNF = British National Formulary[23];eMIT= electronic market information tool[24]; PHS = Public Health Scotland[21]

Inpatient care costs

An appropriate healthcare resource group (HRG) code was identified for each infection[25] to account for costs of inpatient care (appendix 4 table E). Costs were based on a weighted average of excess bed day costs for elective and non-elective inpatient stay across various severity levels (table 8).

Table 8: infection-specific cost of inpatient stay

Condition	Cost	Source
SSTI	£387	NHS England Reference costs, 2019
Complex UTI	£301	
Orthopaedic	£298	
Complex UTI	£301	
Bronchiectasis	£297	
Intra-abdominal	£321	

SSTI = skin and soft tissue infections; UTI = urinary tract infection

A summary of all cost-minimisation model assumptions is available in appendix 4, table F.

Results

Infections requiring short-term treatment

Skin and soft tissue infections (SSTI)

In the UK 7,371 treatment episodes with a mean treatment duration of 6.4 days were recorded in the BSAC national outcomes registry for SSTI in the last five years. This resulted in 47,085 patient bed-days saved across the participating sites.

In the cost-minimisation analysis, patients attending an outpatient clinic once daily for the duration of antimicrobial treatment, were primarily treated with IV ceftriaxone, but also with teicoplanin and daptomycin. Treatment with the same medicines was assumed in the specialist nurse visit model. A small number of patients could also be treated with dalbavancin as a one-off dose. Patients who were offered an elastomeric home infusion device were primarily treated with ceftriaxone once daily and less often with flucloxacillin as 24-hour infusion (see appendix 4, table B for information on dose and frequency of administration). All medicines - apart from flucloxacillin - could also be administered as a bolus IV.

The estimated average cost per SSTI treatment episode in OPAT in the UK was £631 for an outpatient attending a clinic once daily and £831 for the nurse home visit model. The cost of self-administration with bolus IV was £566, and £611 if self-administered via commercially pre-filled elastomeric device (table 9). The cost of treating a patient with one-off dalbavancin was £1,266 as an outpatient. The cost of continuous daily infusion with flucloxacillin as an outpatient was £802. The cost of SSTI treatment as an inpatient would be £2,476 per episode.

Table 9: cost of OPAT models of care versus inpatient stay for short-term SSTI in the UK

Model of care		Cost	Difference compared with inpatient stay	OPAT as % cost of inpatient care
Inpatient stay	Cost per episode	£2,476		
	NORS total	£18,253,696		
OPAT once daily outpatient clinic	Cost per episode	£631	-£1,846	
	NORS total	£4,650,245	-£13,603,451	25%
OPAT specialist nurse daily home visit	Cost per episode	£831	-£1,645	
	NORS total	£6,125,310	-£12,128,386	34%
OPAT self-administration (bolus IV)	Cost per episode	£566	-£1,911	
	NORS total	£4,170,675	-£14,083,021	23%
OPAT self-administration (elastomeric device)	Cost per episode	£611	-£1,865	
	NORS total	£4,506,304	-£13,747,392	25%
OPAT one-off dalbavancin	Cost per episode	£1,266	-£1,210	
	NORS total	£9,335,278	--£8,918,418	51%
OPAT CIVI as an outpatient (elastomeric device)	Cost per episode	£802	-£1,674	
	NORS total	£5,912,090	-£12,341,606	32%

Estimates per individual and for those managed in BSAC NORS participating sites over five years
SSTI=skin and soft tissue; OPAT= outpatient parenteral antimicrobial therapy; CIVI = continuous intravenous infusion; NORS = national outcomes registry system

Complex urinary tract infections (UTI)

In the UK, there were 1,896 OPAT treatment episodes for patients with complex UTI over the last five years and recorded within the BSAC national outcomes registry. The mean duration of treatment was seven days. This resulted in 13,278 bed-days saved across the participating sites.

Patients with complex UTI were primarily treated with ertapenem (90%) and a minority of patients were treated with temocillin. It was assumed in the analysis that patients attending an outpatient clinic daily or being treated by a nurse at home were only given ertapenem, due to temocillin requiring more than once daily administration. Both medicines can be self-administered using a bolus IV. No patients were assumed to be treated using home infusion elastomeric devices.

The per episode estimated cost of treating patients with complex UTI in OPAT in the UK was £758 at an outpatient clinic, £977 for the nurse home visit model, and £720 if self-administered at home (table 10). The cost of equivalent inpatient treatment for complex UTI would be £2,104.

Table 10: cost of OPAT models of care versus inpatient stay for short-term complex UTI infections in the UK

Model of care		Cost	Difference compared with inpatient stay	OPAT as % cost of inpatient care
Inpatient stay	Cost per episode	£2,104		
	NORS total	£3,989,175		
OPAT once daily outpatient clinic visits	Cost per episode	£758	-£1,346	
	NORS total	£1,437,798	-£2,551,377	36%
OPAT specialist nurse daily home visit	Cost per episode	£977	-£1,127	
	NORS total	£1,852,791	-£2,136,383	46%
OPAT self-administration (bolus IV)	Cost per episode	£720	-£1,384	
	NORS total	£1,364,799	-£2,624,376	34%

Estimates per individual and for those managed in BSAC NORS participating sites over five years
UTI=urinary tract infection; OPAT= outpatient parenteral antimicrobial therapy; NORS = national outcomes registry system

Infections requiring longer-term treatment

Orthopaedic (bone and joint) infections

In the UK 5,355 treatment episodes with a mean treatment duration of approximately 28 days were recorded in the BSAC national outcomes registry for the treatment of orthopaedic infections over the last five years. This resulted in 149,084 patient bed-days saved across the participating sites.

In the analysis, patients were assumed to be treated once daily with ceftriaxone, teicoplanin or ertapenem in the outpatient clinic, nurse home visit and self-administration (bolus IV) OPAT service

delivery models. Ceftriaxone was the only antimicrobial used for self-administration via elastomeric device for this type of infection. A model is also presented where patients were treated with oral therapies only or a combination of oral and IV therapies (see appendix 4 table C for oral therapies used in the analysis).

The average estimated cost per treatment episode in OPAT in the UK for orthopaedic infections was £2,506 at an outpatient clinic (once daily visit), £3,375 for the nurse home visit model, £1,855 for bolus IV self-administration, and £2,394 for self-administration with a commercially pre-filled elastomeric device (table 11). The estimated average cost per treatment episode with oral therapies only was £1,114. If a blended treatment approach (oral and IV therapies) was considered, the cost per episode was between £1,410 and £2,009 depending on how quickly a patient switched to oral therapies. The cost of inpatient care would be £8,279 per treatment episode for orthopaedic infections.

Table 11: cost of OPAT models of care versus inpatient stay for longer-term orthopaedic infections in the UK

Model of care		Cost	Difference compared with inpatient stay	OPAT as % cost of inpatient care
Inpatient stay	Cost per episode	£8,279		
	NORS total	£44,333,957		
OPAT once daily outpatient clinic	Cost per episode	£2,506	-£5,773	
	NORS total	£13,420,740	-£30,913,217	30%
OPAT specialist nurse daily home visit	Cost per episode	£3,375	-£4,904	
	NORS total	£18,075,626	-£26,258,331	41%
OPAT self-administration (bolus IV)	Cost per episode	£1,855	-£6,424	
	NORS total	£9,931,850	-£34,402,107	22%
OPAT self-administration (elastomeric device)	Cost per episode	£2,394	-£5,885	
	NORS total	£12,822,294	-£31,511,664	29%
OPAT supervised oral therapies (100%)	Cost per episode	£1,114	-£7,165	
	NORS total	£5,967,800	-£38,366,157	13%
OPAT supervised oral therapies (25% oral, 75% IV)	Cost per episode	£2,009	-£6,270	
	NORS total	£10,759,517	-£33,574,440	24%
OPAT supervised oral therapies (50% oral, 50% IV)	Cost per episode	£1,710	-£6,569	
	NORS total	£9,155,594	-£35,178,363	21%
OPAT supervised oral therapies (75% oral, 25% IV)	Cost per episode	£1,410	-£6,869	
	NORS total	£7,551,670	-£36,782,287	17%

Estimates per individual and for those managed in BSAC NORS participating sites over five years
OPAT= outpatient parenteral antimicrobial therapy; NORS = national outcomes registry system

Diabetic foot infections

In the UK 1,797 treatment episodes with a mean treatment duration of approximately 28 days were recorded in the BSAC national outcomes registry for the treatment of diabetic foot infections over the last five years. This resulted in 50,895 patient bed-days saved across the participating sites.

Similarly to orthopaedic infections, patients with diabetic foot infections were assumed to be treated with ceftriaxone, ertapenem or teicoplanin, although the proportion of patients treated with each agent varied (see appendix 4 table D). All three antimicrobial medicines were suitable for once daily administration.

The estimated average cost per treatment episode for diabetic foot infections in OPAT in the UK was £2,671 at an outpatient clinic (once daily visit), £3,556 for the nurse home visit model, £2,006 for bolus IV self-administration, and £2,433 for self-administration with commercially pre-filled elastomeric device (table 12). The estimated average cost per treatment episode with oral therapies only was £1,089. If a blended treatment approach (oral and IV therapies) was considered, the cost per episode was between £1,470 and £2,161 depending on how quickly a patient switched to oral therapies. The cost of an inpatient stay for this infection type would be £8,428.

Table 12: cost of OPAT models of care versus inpatient stay for longer-term diabetic foot infections in the UK

Model of care		Cost	Difference compared with inpatient stay	OPAT as % cost of inpatient care
Inpatient stay	Cost per episode	£8,428		
	NORS total	£15,144,911		
OPAT once daily outpatient clinic	Cost per episode	£2,671	-£5,757	
	NORS total	£4,800,004	-£10,344,907	32%
OPAT specialist nurse daily home visit	Cost per episode	£3,556	-£4,872	
	NORS total	£6,390,158	-£8,754,753	42%
OPAT self-administration (bolus IV)	Cost per episode	£2,006	-£6,422	
	NORS total	£3,604,176	-£11,540,735	24%
OPAT self-administration (elastomeric device)	Cost per episode	£2,433	-£5,995	
	NORS total	£4,372,347	-£10,772,564	29%
OPAT supervised oral therapies (100%)	Cost per episode	£1,089	-£7,339	
	NORS total	£1,957,424	-£13,187,487	13%
OPAT supervised oral therapies (25% oral, 75% IV)	Cost per episode	£2,161	-£6,267	
	NORS total	£3,883,574	-£11,261,337	26%
OPAT supervised oral therapies (50% oral, 50% IV)	Cost per episode	£1,816	-£6,612	
	NORS total	£3,262,630	-£11,882,281	22%

OPAT supervised oral therapies (75% oral, 25% IV)	Cost per episode	£1,470	-£6,958	
	NORS total	£2,641,686	-£12,503,225	17%

Estimates per individual and for those managed in BSAC NORS participating sites over five years
OPAT= outpatient parenteral antimicrobial therapy; NORS = national outcomes registry system

Bronchiectasis

For the treatment of bronchiectasis, 4,096 treatment episodes were recorded in the BSAC national outcomes registry in the UK in the last five years, with a mean duration of treatment of 11 days. This resulted in 44,866 bed-days saved across the participating sites.

In the analysis, patients were assumed to be treated with ceftazidime, meropenem, or piperacillin with tazobactam. All medications were suitable for self-administration as a bolus IV. Only piperacillin with tazobactam was assumed to be administered using an elastomeric device via 24-hour continuous infusion. Since all of the medications for this infection type required more than once daily administration or continuous daily infusion, the outpatient clinic and nurse home visits OPAT service models are highly unlikely to be used in clinical practice. However, it is possible that suitable patients could attend an outpatient clinic once daily where a nurse would administer piperacillin with tazobactam as 24-hour continuous infusion through an elastomeric device. The per episode estimated cost for the same treatment plan with a nurse home visit is also presented.

The per episode cost of treating patients with bronchiectasis with continuous IV infusion using an elastomeric device in OPAT in the UK was £1,495 in an outpatient clinic and £1,839 for nurse home visits. The per episode cost of treatment was £1,301 if self-administered using bolus IV and £1,588 if self-administered at home using a commercially pre-filled elastomeric device (table 13). The cost of equivalent inpatient treatment for bronchiectasis would be £3,269.

Table 13: cost of OPAT models of care versus inpatient stay for longer-term bronchiectasis in the UK

Model of care		Cost	Difference compared with inpatient stay	OPAT as % cost of inpatient care
Inpatient stay	Cost per episode	£3,269		
	NORS total	£13,391,229		
OPAT CIVI at outpatient clinic (elastomeric device)	Cost per episode	£1,495	-£1,775	
	NORS total	£6,122,489	-£7,268,741	46%
OPAT specialist nurse daily home visit (CIVI)	Cost per episode	£1,839	-£1,431	
	NORS total	£7,531,315	-£5,859,915	56%
OPAT self-administration (bolus IV)	Cost per episode	£1,301	-£1,969	
	NORS total	£5,327,108	-£8,064,121	40%
OPAT self-administration (elastomeric device)	Cost per episode	£1,588	-£1,682	
	NORS total	£6,503,673	-£6,887,556	49%

Estimates per individual and for those managed in BSAC NORS participating sites over five years

OPAT= outpatient parenteral antimicrobial therapy; CIVI = continuous intravenous infusion; NORS = national outcomes registry system

Intra-abdominal infections

For the treatment of intra-abdominal infections, 1,117 treatment episodes were recorded in the BSAC national outcomes registry in the UK in the last five years, with a mean duration of treatment of 22 days. This resulted in 24,837 bed-days saved across the participating sites.

In the cost-minimisation analysis, patients were primarily treated with ertapenem or piperacillin with tazobactam. The latter was assumed to be used only in patients who were suitable for self-administration or to attend a clinic daily for a change of elastomeric device. Patients who attended an outpatient clinic daily for bolus IV infusions or who received nurse visits were assumed to be treated with ertapenem.

The per episode cost of treating patients with complex intra-abdominal infections in OPAT in the UK was £2,312 at an outpatient clinic (once daily visits), £3,006 for the specialist nurse home visits model, £1,811 for self-administration using bolus IV at home, £2,952 for self-administration at home using an elastomeric device, and £2,807 for elastomeric device filled by hospital staff in an outpatient setting (table 14). The cost of equivalent inpatient treatment would be £7,124.

Table 14: cost of OPAT models of care versus inpatient stay for longer-term intra-abdominal infections in the UK in the last five years

Model of care		Cost	Difference compared with inpatient stay	OPAT as % cost of inpatient care
Inpatient stay	Cost per episode	£7,124		
	NORS total	£7,957,287		
OPAT once daily outpatient clinic	Cost per episode	£2,312	-£4,811	
	NORS total	£2,582,872	-£5,374,415	32%
OPAT specialist nurse daily home visit	Cost per episode	£3,006	-£4,117	
	NORS total	£3,358,246	-£4,599,042	42%
OPAT self-administration (bolus IV)	Cost per episode	£1,811	-£5,313	
	NORS total	£2,023,190	-£5,934,097	25%
OPAT self-administration (elastomeric device)	Cost per episode	£2,952	-£4,171	
	NORS total	£3,297,898	-£4,659,389	41%
OPAT continuous infusion as an outpatient (elastomeric device)	Cost per episode	£2,807	-£4,317	
	NORS total	£3,134,895	-£4,822,392	39%

Estimates per individual and for those managed in BSAC NORS participating sites over five years
OPAT= outpatient parenteral antimicrobial therapy; CIVI = continuous intravenous infusion; NORS = national outcomes registry system

Scenario analyses

Scenario analyses are described in tables 15 and 17. Within these analyses, assumptions used in the original modelling are varied to assess their impact on base case results. The results of the scenario analyses show OPAT cost as a percentage of the equivalent cost of an inpatient stay (tables 16 and 17). Scenarios 1 and 2 use the bed-day cost associated with inpatient stay in an infectious disease unit regardless of diagnosis. Scenario 2 also uses the cost of an outpatient appointment at an infectious disease unit. Results from the scenarios are consistent with the base case findings.

Based on the modelling approach used in the analysis, one of the uncertainties relates to the extent of overhead costs per patient. The model's base case assumes a standard day rate for healthcare services in the NHS regardless of infection type or OPAT model of care. Chapman *et al* (2009) reported overhead and support costs in their infectious disease unit to be 44.8% of total costs excluding rehospitalisation.[18] When the equivalent assumption was applied to our model, the cost of treatment episode in OPAT remained less than 52% of the cost of inpatient care across all scenarios, except for bronchiectasis treated with continuous intravenous infusion using an elastomeric device with patients visiting an outpatient clinic once daily (scenario 3).

There are uncertainties around the source of cost for linezolid for the oral treatment of orthopaedic infections and diabetic foot infections (scenario 4). The cost reported in the British National Formulary[23] is substantially higher than that advised by clinicians and the cost reported in the electronic market information tool (eMIT)[24] which has been used in the base case analysis. Using the alternative source of cost for linezolid did not alter the results of the analysis. Variations in the treatment protocol for dalbavancin seems to have the highest impact on costs of treatment of SSTI in OPAT due to the high medicine acquisition cost (scenarios 6 and 7, table 18).

Table 15: scenario analyses for OPAT outpatient clinics versus inpatient care

	Scenario	Base case
0	Base case (outpatient)	
1	Using cost of inpatient care in an IDU of £474[21]	Using condition-specific healthcare resource group (HRG) costs[25]
2	Using Public Health Scotland[21] cost for outpatient appointments* and inpatient stay in an infectious disease unit	Using micro-costing of nurse and consultant outpatient appointments
3	Assuming overheads are 44.8% of total costs consistent with a published source[18]	Assuming per day cost of using healthcare services consistent with a published source[4]
4	Using BNF[23] as the source for the cost of linezolid (orthopaedic and diabetic foot infections)	Using eMIT[24] as the source for the cost of linezolid (orthopaedic and diabetic foot infections)

IDU = infectious disease unit; PHS = Public Health Scotland; BNF = British National Formulary; eMIT = electronic market information tool

***£94 - nurse-led appointment; £287 – consultant-led appointment*

Table 16: results for scenarios 1-4

	SSTI	Complex UTI	Orthopaedic	Diabetic foot	Bronchiectasis	Intra-abdominal
0	25%	36%	30%	32%	44%	32%
1	21%	25%	22%	22%	34%	24%
2	20%	28%	24%	24%	31%	25%
3	33%	52%	40%	44%	77%	46%
4	-	-	21%	21%	-	-

SSTI = skin and soft tissue infections; UTI = urinary tract infections

Table 17: scenarios 5-7 with results for OPAT outpatient vs. inpatient care for SSTI

	Scenario	Base case	SSTI
0	Base case		25%
5	Including the cost of consultant time	Nurse-led care; no consultant time	28%
6	Using the licensed one-off dose of dalbavancin (1.5g)	Using one-off dalbavancin 1g as treatment consistent with clinical practice	74%
7	Using the licensed dose of dalbavancin 1g followed by 0.5g	Using one-off dalbavancin 1g as treatment consistent with clinical practice	76%

SSTI = skin and soft tissue infections

Discussion (of cost-minimisation analysis)

The cost-minimisation analysis found that all OPAT delivery models were substantially cheaper than inpatient care of equivalent duration across a range of infections. Using five years of activity data from the BSAC national outcomes registry, the analysis showed that OPAT has the potential to bring substantial savings to the NHS in the UK. The extent of savings is expected to vary with choice of OPAT delivery model. The analysis estimated costs associated with providing IV antimicrobials via an OPAT service to be in the range of 25% to 32% of the cost of inpatient care for the treatment of SSTI, 34% to 46% for complex UTI, 22% to 42% for orthopaedic and diabetic foot infections (longer-term), 40% to 56% for bronchiectasis, and 25% to 42% for intra-abdominal infections. Overall, across all infections considered in the analysis, OPAT had the potential to generate approximately £60k to £75k savings to the NHS over five years, depending on the model of care (appendix 4 table G).

Other key findings from the SHTG *de novo* economic analysis are that the self-administration (bolus IV) model of care was associated with the lowest cost and nurse home visits the highest estimated cost per treatment episode across all infection types. Of all the available OPAT treatment options for patients with SSTI, one-off treatment with dalbavancin was estimated to have the highest cost. Only a small proportion of patients (approximately 5%) are treated with dalbavancin in clinical practice (Dr A Seaton, Consultant in Infectious Diseases and General Medicine, NHS Greater Glasgow and Clyde. Personal communication, 13 August 2020).

The model also took into account oral treatment options. Oral therapy OPAT was the cheapest treatment option for patients with orthopaedic (bone and joint) or diabetic foot infection. If patients were switched from IV OPAT to oral therapies at least half way through their treatment duration, the analysis showed that the cost per treatment episode is lower than the cost of self-administering IV therapy for the whole treatment duration.

The cost-minimisation analysis has several limitations. The assumption of equivalence in patient and treatment outcomes for OPAT and inpatient care, as well as among various models of OPAT care, is based on published systematic reviews[3,13,14] but direct comparative evidence is lacking. There is one systematic review[4] that suggests that a specialist OPAT nurse visit model is associated with better outcomes compared with other OPAT delivery models. A published source[25] was used for the cost of inpatient stay, which is inconsistent with the bottom-up costing approach undertaken for the cost of OPAT. The assumption that the cost of bed-days in the analysis is equivalent to the cost of excess bed-days as reported in NHS England reference costs[25] is associated with uncertainties due to the structure of the reimbursement system in NHS England. Nevertheless, this is considered to be the most suitable published source of costs of inpatient care as it provided cost estimates for each of the six infection categories in the analysis. The estimated average costs per treatment episode in OPAT aim to reflect existing OPAT services and thus set up and implementation costs have not been considered.

Patient and social aspects

Four qualitative studies, two based on the same data, explored patient experiences and preferences in relation to OPAT services in the UK.[4, 13, 26, 27]

The qualitative analysis reported in two separate publications, performed 28 semi-structured interviews, face-to-face or by telephone, and one focus group (n=4) exploring adult patient experiences of OPAT in NHS England.[4, 27] The purposive sample in this study included patients on both short term (<7 days, n=20) and longer-term (>14 days, n=12) IV antimicrobial therapy. Interviews lasted 30-75 minutes and were conducted by four different researchers. The focus group ran for 95 minutes. Study participants (n=32) had a mean age of 53 (range 21 to 80), 50% were male, and almost all (n=31) were white. Fourteen participants attended an outpatient clinic for their treatment, 13 were visited by a nurse (specialist or general) at home, and five people self-administered OPAT at home.

Patients viewed each model of OPAT care as having both strengths and weaknesses. The importance attached to different attributes was linked to the age and general health of the patient. The main perceived benefits of OPAT, regardless of model of care, were avoiding unnecessary hospital admissions, being able to enjoy the comforts of home, and reduced disruptions to daily life (including work). Clear communication between the OPAT team and patients, the ability to ask questions, and follow-up at the end of treatment, were highlighted as important to patients. Communication became increasingly important if things went wrong or recovery was not as the patient expected. The majority of long-term OPAT patients were reviewed regularly. However, most

patients with short-term infections reported not being seen by a healthcare professional at the end of their treatment. Follow-up at the end of treatment was particularly important to patients who had not been reviewed face-to-face during their treatment.

Older participants often put caveats on when OPAT would be most suitable. These caveats included the severity of infection, the patient's general health, the number of infusions required per day, and family circumstances. Nurses (specialist or general) administering OPAT in a patient's home were deemed most suitable for the very elderly or infirm. Some patients found home treatment by a nurse more convenient and less stressful than attending a hospital clinic, however when nurses were late or failed to attend this was a significant source of worry and frustration. Younger patients appeared to prefer daily outpatient attendance for OPAT as they felt this caused the least disruption to their life. Other patients felt that attending a daily or twice-daily outpatient clinic would be as bad as being an inpatient. One perceived benefit of attending an outpatient clinic was that problems could be dealt with promptly. Participants who self-administered OPAT all had recurrent infections and had been administering their own treatment for years, however some would like to have the option to stop self-administration in future. Few patients realised how challenging it would be to have OPAT at home.

Concerns voiced by study participants included travel to attend clinics, the impact of OPAT on family and friends, the perceived risk of hospital-acquired infections, fears about returning to daily life with a cannula or venous access device, and perceived premature transition from IV to oral antimicrobials. Travel posed a particular challenge to patients who relied on public transport. Concerns about the impact on friends and family of providing practical and psychological support to OPAT patients led many patients to express a sense of guilt. Participants were at an increased risk of contracting infections due to underlying health issues and knew being treated at home reduced this risk. The nurse administration at home model of care was therefore perceived to be safe because it minimised the risk of contracting *C.difficile* or MRSA.

The second qualitative study explored experiences among a group of adult OPAT patients attending an outpatient clinic in the north-east of Scotland.[13] Self-administration of OPAT was an option within this service, but uptake for this option had declined from 53% in 2006 to 24% in 2015. A single interviewer conducted face-to-face semi-structured interviews with a purposive sample of patients undergoing OPAT for a minimum of seven days. Two pilot interviews assessed patient understanding of the questions and then an initial sample of 10 patients was expanded until data saturation was achieved (n=20). Each interview lasted 30-45 minutes.

Study participants had a mean age of 54 (standard deviation (SD) ± 17.6), 65% were male, and almost half (n=9) were being treated for bone or joint infections. Themes identified in the analysis of patient interviews in this study are summarised in table 18. From a patient perspective, the main reasons for not self-administering OPAT were a lack of awareness it was an option, a perception that hospital staff were the most appropriate people to deliver OPAT, and anxiety about potential complications with self-administration. When patients became aware that self-administration was an option, some indicated they would have liked to self-administer, while others did not believe they were capable of self-administration, citing reasons such as complex home circumstances and

physical inability. Some patients felt that self-administration could improve their quality of life by facilitating their return to work, reducing the impact on social and family life, and reducing travel time.

Many patients did not remember being involved in the decision whether to have OPAT in the hospital or at home, but most expressed confidence that the healthcare professionals knew best. It is possible this perception of not being consulted was affected by recall bias. Some study participants indicated they would continue to opt for outpatient clinic-based OPAT if they needed further treatment. This view was sometimes a result of experiencing a social benefit from getting out of the house and meeting people at the clinic.

Table 18: summary of the barriers and facilitators to self-administration of OPAT at home[13]

Theme
Facilitators
Belief and confidence in abilities / Perception that they have the skills required to self-administer
Belief that self-administration could improve quality of life
Lack of parking on hospital grounds and distance from parking to clinic
Staff reassurance, encouragement, support and training
Barriers
Lack of awareness of self-administration option
Lack of confidence in abilities
Belief that healthcare professionals should administer OPAT
Belief that it is safer to administer IV medications in hospital (cleaner environment and fewer negative consequences)
Anxiety and stress associated with self-administration (fear of using and handling needles, concern about complications)
Influence of family and friends
Lack of patient involvement in decision making
Facilitator or barrier
Complex home circumstances (dependents)
Experiences of attending OPAT clinic (including social benefits of clinic attendance)

The final study explored the views of parents and children about paediatric OPAT services in England.[26] The OPAT service in this study was delivered once a day by a children's community nurse visiting the patient's home. Parents of children treated with OPAT in 2017-2018, who had completed a survey as part of a larger study, were invited to participate in a face-to-face interview within four

weeks of their child completing OPAT. Twelve parents of 10 children (10 mothers and two fathers) were interviewed. One 15-year old was interviewed alongside her mother. Children in the study sample were aged five weeks to 15 years old (six were aged 4-7 years). They received OPAT lasting between one and 21 days, with a mean of 8.3 days.

Overall there was a clear sense that home was where parents and children preferred to be. Parents were generally keen to leave the hospital and return home as they had been existing in 'survival mode', were exhausted, and had often been separated from other family members. Being at home generated a sense of comfort and security, which parents felt enhanced recuperation of their child, and allowed the family to regain a sense of normality. Parents were able to recover from the stress of their child's illness and regain control of facets of daily life, such as food choices and bed times. There was a sense of mild inconvenience in needing to be available for daily nurse visits, but overall parents seemed happy with their decision to have OPAT at home. Few parents expressed any reluctance to having home-based OPAT again if needed, as they felt the hospital was not the best place for a recovering child and their family.

Good communication between the hospital and community services prior to discharge and once a child had returned home underpinned parents' confidence in the service. Communications were perceived to focus on IV access, preserving access, and keeping the child safe. Most parents had little recollection of being given information about possible adverse events. Any concerns parents had about home-based OPAT were perceived by them to be minor and manageable. Concerns included line-related issues, such as the child knocking it out, cleanliness of the home environment, and the space required for boxes of equipment. Some parents reported barriers to children returning to normal activities, such as school, while having OPAT.

Inequity of access

Health inequity is defined as "differences in healthcare that are avoidable, unnecessary and unjust". A study conducted in NHS Lothian identified significant inequities in access to local OPAT services based on socioeconomic status and gender.[28] The study cohort comprised all inpatients aged 13 or older who were admitted for treatment of cellulitis between 2012 and 2017. There were 4,944 patients in the univariate analysis and 4,902 in the multivariate analysis. The multivariate analysis adjusted for age, gender, Scottish Index of Multiple Deprivation (SIMD) category, distance to the nearest OPAT clinic, time since first admission, total admissions, total comorbidities, and total length of stay. Fifteen percent (n=729) of patients with cellulitis were referred to OPAT services. Median distance from home to the nearest OPAT centre was 6.8 km (IQR 3.8 km to 13.0 km), 53% of patients were male, and median length of initial hospital stay was four days (IQR two to 10 days).

There was a significant linear correlation between deprivation status (measured using the SIMD) and cellulitis hospital admissions, $p<0.0001$. An individual from the most deprived SIMD quintile was seven times more likely not to be referred to OPAT than to be referred. A female patient with cellulitis was 7.5 times more likely not to be referred to OPAT than to be referred. In multivariate analysis, patients with cellulitis who were in the least deprived SIMD category were twice as likely to be referred to OPAT services as a patient from the most deprived quintile: adjusted odds ratio (OR)

2.08, 95% confidence interval (CI) 1.60 to 2.71, p<0.0001. Female patients with cellulitis were significantly less likely than male patients to be referred to OPAT services: adjusted OR 0.69, 95% CI 0.58 to 0.82, p<0.001.

Reasons for the apparent inequity in referrals to OPAT services in this patient cohort are unclear. It is possible some patients were not referred based on local OPAT exclusion criteria. The study authors noted that inequities described in this study may not apply to other types of infection, but if they do, the current policy of increased care closer to home may inadvertently widen healthcare inequities in Scotland.

Conclusion

Although OPAT services are established in many countries, including Scotland, conclusive evidence on the clinical benefits and effectiveness of OPAT compared with inpatient care is currently not available due to a lack of published comparative studies. There is selection bias in the available comparative studies since patients are generally allocated to inpatient care or OPAT based on clinical characteristics, leading to differences in underlying patient populations in the two settings. Based on the comparative evidence available, systematic reviews suggest minimal differences between OPAT and inpatient care in terms of duration of therapy for adults. Results for hospital readmission rates and mortality in adults were inconclusive. Evidence on the safety of OPAT is similarly restricted to observational evidence. Vascular access device-related complications and drug-related adverse events are the most commonly reported safety issues in OPAT, however it remains unclear how rates compare with the inpatient setting.

The evidence exploring the relative effectiveness and safety of different models of OPAT care is even more limited. The only evidence identified in the literature search was a systematic review that focused on comparison of individual OPAT models with inpatient care. This systematic review concluded that OPAT services delivered via outpatient clinics appeared to be the least effective model, and specialist nurse administered OPAT at home was the most effective model of care. This is in contrast to the current provision of OPAT services in Scotland and England which are mainly based in outpatient clinics. The results of the review should be interpreted cautiously since comparisons and conclusions were based on very few (n<4) studies.

All of the models of OPAT care described in the literature have advantages, disadvantages, and unique factors to consider, such as travel for outpatient attendance or refrigeration for home-based care. It is likely, based on the literature reviewed, that the best approach to delivering an OPAT service would be to offer more than one model of care within a single service to match patient needs. For example a service based mainly on outpatient clinic attendance may offer self-administration at home to eligible patients.

In the SHTG *de novo* cost-minimisation comparisons of OPAT with inpatient care in the UK, OPAT models were consistently less expensive. The extent of cost reductions associated with OPAT relative to inpatient care was sensitive to the underlying infection and model of OPAT care.

Qualitative evidence indicates that patients perceive a number of benefits from OPAT services, including avoiding hospital admission and reducing disruption to daily life. Concerns identified by patients about OPAT were generally perceived by patients to be minor and manageable.

OPAT services align with the Scottish policy context in terms of the shift from hospital-based healthcare to care closer to home. Evidence from a study in Lothian suggests care needs to be taken to ensure equity of access to OPAT services for all eligible patients.

Equality and diversity

Healthcare Improvement Scotland is committed to equality and diversity in respect of the nine equality groups defined by age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion, sex, and sexual orientation.

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To propose a topic for SHTG consideration, email his.shtg@nhs.scot

References can be accessed via the internet (where addresses are provided), via the NHS Knowledge Network www.knowledge.scot.nhs.uk, or by contacting your local library and information service.

A glossary of commonly used terms in Health Technology Assessment is available from htaglossary.net.

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References

1. 1. Health Protection Scotland. Scottish One Health antimicrobial use and antimicrobial resistance in 2018: annual report. 2019 [cited 2020 Oct 26]; Available from: https://hpspubsrepo.blob.core.windows.net/hps-website/nss/2894/documents/2_2019-11-12-SONAAR-2018-Report.pdf.
2. 2. Seaton RA, Barr DA. Outpatient parenteral antibiotic therapy: principles and practice. Eur J Intern Med. 2013;24(7):617-23.
3. 3. Chapman ALN. Outpatient parenteral antimicrobial therapy. BMJ. 2013;346:f1585.
4. 4. Minton J, Czoski Murray C, Meads D, Hess S, Vargas-Palacios A, Mitchell E*, et al.* The Community IntraVenous Antibiotic Study (CIVAS): a mixed-methods evaluation of patient preferences for and cost-effectiveness of different service models for delivering outpatient parenteral antimicrobial therapy. 2017 [cited 2020 Dec 01]; Available from: https://www.journalslibrary.nihr.ac.uk/hsdr/hsdr05060/#/abstract.
5. 5. Bryant PA, Katz NT. Inpatient versus outpatient parenteral antibiotic therapy at home for acute infections in children: a systematic review. Lancet Infect Dis. 2018;18(2):e45-54.
6. 6. Chapman ALN, Patel S, Horner C, Green H, Guleri A, Hedderwick S*, et al.* Updated good practice recommendations for outpatient parenteral antimicrobial therapy (OPAT) in adults and children in the UK. JAC Antimicrob Resist. 2019;1(2):dlz026.
7. 7. British Society for Antimicrobial Chemotherapy. National outcomes registry system (NORS). c2019 [cited 2020 Oct 26]; Available from: https://www.e-opat.com/opat-registry/.
8. 8. Gilchrist M, Seaton RA. Outpatient parenteral antimicrobial therapy and antimicrobial stewardship: challenges and checklists. J Antimicrob Chemother. 2015;70(4):965-70.
9. 9. Seaton RA, Ritchie ND, Robb F, Stewart L, White B, Vallance C. From 'OPAT' to 'COpAT': implications of the OVIVA study for ambulatory management of bone and joint infection. J Antimicrob Chemother. 2019;74(8):2119-21.
10. 10. Barr DA, Semple L, Seaton RA. Outpatient parenteral antimicrobial therapy (OPAT) in a teaching hospital-based practice: a retrospective cohort study describing experience and evolution over 10 years. Int J Antimicrob Agents. 2012;39(5):407-13.
11. 11. Mitchell ED, Czoski Murray C, Meads D, Minton J, Wright J, Twiddy M. Clinical and cost-effectiveness, safety and acceptability of community intravenous antibiotic service models: CIVAS systematic review. BMJ Open. 2017;7(4):e013560.
12. 12. Sriskandarajah S, Hobbs J, Roughead E, Ryan M, Reynolds K. Safety and effectiveness of 'hospital in the home' and 'outpatient parenteral antimicrobial therapy' in different age groups: a systematic review of observational studies. Int J Clin Pract. 2018:e13216.
13. 13. Tonna A, Anthony G, Tonna I, Paudyal V, Forbes-Mckay K, Laing R*, et al.* Home self-administration of intravenous antibiotics as part of an outpatient parenteral antibiotic therapy service: a qualitative study of the perspectives of patients who do not self-administer. BMJ Open. 2019;9(1):e027475.
14. 14. Keller SC, Cosgrove SE, Kohut M, Krosche A, Chang HE, Williams D*, et al.* Hazards from physical attributes of the home environment among patients on outpatient parenteral antimicrobial therapy. Am J Infect Control. 2019;47(4):425-30.
15. 15. Carter B, Carrol ED, Porter D, Peak M, Taylor-Robinson D, Fisher-Smith D*, et al.* Delivery, setting and outcomes of paediatric Outpatient Parenteral Antimicrobial Therapy (OPAT): a scoping review. BMJ Open. 2018;8(11):e021603.
16. 16. Durojaiye OC, Bell H, Andrews D, Ntziora F, Cartwright K. Clinical efficacy, cost analysis and patient acceptability of outpatient parenteral antibiotic therapy (OPAT): a decade of Sheffield (UK) OPAT service. Int J Antimicrob Agents. 2018;51(1):26-32.
17. 17. Seaton RA, Johal S, Coia JE, Reid N, Cooper S, Jones BL. Economic evaluation of treatment for MRSA complicated skin and soft tissue infections in Glasgow hospitals. Eur J Clin Microbiol Infect Dis. 2014;33(3):305-11.

18. 18. Chapman ALN, Dixon S, Andrews D, Lillie PJ, Bazaz R, Patchett JD. Clinical efficacy and cost-effectiveness of outpatient parenteral antibiotic therapy (OPAT): a UK perspective. J Antimicrob Chemother. 2009;64(6):1316-24.
19. 19. Allwood MC, Stonkute D, Wallace A, Wilkinson AS, Hills T, Jamieson C. Assessment of the stability of citrate-buffered flucloxacillin for injection when stored in two commercially available ambulatory elastomeric devices: INfusor LV (Baxter) and Accufuser (Woo Young Medical): a study compliant with the NHS Yellow Cover Document (YCD) requirements. Eur J Hosp Pharm. 2018;27(2):90-4.
20. 20. Jamieson C, Ozolina L, Seaton RA, Gilchrist M, Hills T, Drummond F*, et al.* Assessment of the stability of citrate-buffered piperacillin/tazobactam for continuous infusion when stored in two commercially available elastomeric devices for outpatient parenteral antimicrobial chemotherapy: a study compliant with the NHS Yellow Cover Document requirements. Eur J Hosp Pharm. 2020;[in press].
21. 21. Public Health Scotland. Cost books 2018/19: detailed tables. 2019 [cited 2020 October 28]; Available from: https://www.isdscotland.org/Health-Topics/Finance/Costs/Detailed-Tables/.
22. 22. Personal Social Services Research Unit (PSSRU). Unit costs of health and social care. 2020 [cited 2020 October 28]; Available from: https://www.pssru.ac.uk/project-pages/unit-costs/.
23. 23. BNF: British national formulary. 2020 [cited 2020 October 28]; Available from: https://bnf.nice.org.uk.
24. 24. Department of Health and Social Services. Drugs and pharmaceutical electronic market information tool (eMIT). 2020 [cited 2020 October 28]; Available from: https://www.gov.uk/government/publications/drugs-and-pharmaceutical-electronic-market-information-emit.
25. 25. NHS Digital. Reference costs: 2019-20 reference costs collection. 2020 [cited 2020 October 28]; Available from: https://digital.nhs.uk/data-and-information/data-collections-and-data-sets/data-collections/reference-costs.
26. 26. Carter B, Fisher-Smith D, Porter D, Lane S, Peak M, Taylor-Robinson D*, et al.* Being 'at-home' on outpatient parenteral antimicrobial therapy (OPAT): a qualitative study of parents' experiences of paediatric OPAT. Arch Dis Child. 2020;105(3):276-81.
27. 27. Twiddy M, Czoski Murray CJ, Mason SJ, Meads D, Wright JM, Mitchell ED*, et al.* A qualitative study of patients' feedback about Outpatient Parenteral Antimicrobial Therapy (OPAT) services in Northern England: implications for service improvement. BMJ Open. 2018;8(1):e019099.
28. 28. Sumpter C, Russell CD, Mackintosh C. Inequitable access to an outpatient parenteral antimicrobial therapy service: linked cross-sectional study. Int J Equity Health. 2020;19:150.

Appendix 1: abbreviations

BNF	British National Formulary
BSAC	British Society for Antimicrobial Chemotherapy
CDI	*Clostridium difficile* infection
CI	confidence interval
CIVI	continuous intravenous infusion
CRP	c-reactive protein
DES	discrete event simulation
ESD	early supported discharge
FBC	full blood count
GGC	Greater Glasgow and Clyde
GRADE	Grading of Recommendations Assessment, Development and Evaluation
HCITH	healthcare in the home
HR	hazard ratio
HRG	healthcare resource group
IDU	infectious disease unit
IQR	inter-quartile range
ISD	Information Services Division
IV	intravenous
LFT	liver function tests
MAU	medical assessment unit
MDT	multi-disciplinary team
MRSA	methicillin-resistant *Staphylococcus aureus*
NORS	National Outcomes Registry System

OPAT	outpatient parenteral antimicrobial therapy
OR	odds ratio
PICC	peripherally inserted central catheter
PSSRU	Personal Social Services Research Unit
QALY	quality adjusted life-year
RCT	randomised controlled trial
SAPG	Scottish Antimicrobial Prescribing Group
SD	standard deviation
SIMD	Scottish Index of Multiple Deprivation
SSTI	skin and soft tissue infections
UE	urea and electrolytes
UTI	urinary tract infection
VAD	vascular access device
WTE	whole time equivalent

Appendix 2: individual study results from systematic reviews

Table A: efficacy of OPAT versus inpatient care in adults[4]

Study design	OPAT model(s)	n patients (OPAT)	n patients (comparator)	Findings
Observational (retrospective)	Self-administered	8	14 combined tx 29 inpatients	No statistically significant difference between groups in respiratory function tests. There was a significantly greater improvement in respiratory function in the hospital group.
RCT	General nurse	98	96 inpatients	No significant difference in mean days to no advancement of cellulitis between groups (1.50 days vs. 1.49 days; 95% CI –0.3 to 0.28). No significant difference in days on IV antibiotics (hazard ratio (HR) 0.84, 95% CI 0.63 to 1.12; p = 0.23). 11/98 patients in the home group (12%) were admitted to hospital. 3/96 hospital patients (3%) required readmission within one month.
Before and after	Specialist nurse	92 pneumonia 64 cellulitis	10,728 pneumonia ? cellulitus	45/64 (70%) OPAT cellulitis patients required 2 day's treatment (range 2–6 days). Among pneumonia patients 58% (53/92) required ≤ 3 days of treatment (range 2–9 days). 2/92 patients with pneumonia were readmitted (rate over 30-day period = 2%). 69/933 comparator group patients were readmitted (7.4%). 6 cellulitis patients were hospitalised briefly (9.4%). There were no deaths among OPAT patients.

Controlled trial	Self-administered	15	15 inpatients	No significant difference between groups in mean duration of treatment: 14 days (range 10–18 days) vs. 15 days (range 10–25 days). Improved lung function was significantly greater in the hospital group (p = 0.01). There were no drug reactions, IV line problems or sepsis reported in either group.
Case-control	Specialist nurse	50	50 inpatients	No significant difference between groups in median duration of treatment (8 days vs. 9 days). Median duration of fever was significantly shorter in home patients (2 days vs. 5 days; p = 0.00003). No significant difference in mucositis (24% vs. 34%), diarrhoea (35% vs. 39%) or bacteraemia. Four home patients (8%) were readmitted. No patients in either group died.
Observational (retrospective)	Specialist nurse	55 cellulitis 14 pyelonephritis	22 cellulitis inpatients 10 pyelonephritis inpatients	Full recovery was expected in 51/55 home cellulitis patients (93%); the remaining four showed recovery back to a stable pre-existing condition. Recovery was expected in all 22 hospital patients. Recovery was expected in 13/14 home pyelonephritis patients (93%), and in 9/10 hospital patients (90%). The remaining patient in each group was expected to return to a stable pre-existing condition. Mean time to febrifuge was lower for home cellulitis (1.96 days vs. 2.00 days) and pyelonephritis patients (1.79 days vs. 2.40 days), although the difference was not statistically significant. Four hospital patients (three with cellulitis, one with pyelonephritis) were readmitted within 4 weeks.

Case-control	Self-administered	25	25 inpatients	Mean duration of treatment was similar in the two groups (14.1 days vs. 16.7 days). There was no difference between groups in adjusted mean improvement in respiratory outcome variables. The only variable to show a significant difference was total white cell count (–3.64 vs. –4.72, $p < 0.05$).
RCT	Outpatient clinic	40	44 inpatients	Median duration of treatment was similar (6.0 days vs. 6.3 days). Treatment was successful in 34/38 OPAT patients (89%) and 40/42 inpatients (95%). Three events (one OPAT, two inpatient) were considered to be potentially drug related; two events were severe (one in each group). There was one death in the OPAT group.
RCT	Self-administered / specialist nurse	103	97 inpatients	OPAT patients received longer courses of antibiotics (mean 25.4 days vs. 13.5 days, $p < 0.001$). There was a higher rate of clinical success among OPAT patients (89/103, 86.4%) than hospital patients (54/97, 55.7%, $p < 0.001$). 18/103 OPAT patients (17.5%) required readmission. Fewer deaths occurred in the OPAT group (n=4, 3.9%) than in the hospital group (n=18, 18.6%), $p = 0.001$.
RCT	General nurse	24	25 inpatients	There was no difference in the number of days on IV antibiotics (3 days vs. 2 days, $p = 0.22$). At 2 weeks, there was no difference in patient-rated symptoms. There was no difference in time to resolution of fever, tachycardia or tachypnea.

				2/24 patients were readmitted (one with pulmonary infection). One hospital patient was readmitted (clinical deterioration). There were no deaths in either group.
Before and after	Specialist nurse	Standard OPAT 230	Nurse-led OPAT 112	Total median duration of IV therapy was reduced from 5 days (range 1–37 days) to 4 days (range 1–23 days), p = 0.01. Median duration of outpatient therapy was reduced from 4 days (range 1–37 days) to 3 days (range 1–22 days), p = 0.02. Cure or improvement was similar for pre- and post-protocol patients (99% vs. 97%). Re-admission 6% vs. 7%. Drug reactions 4% vs. 7%.
RCT	Outpatient clinic	IV therapy 47	Oral therapy 49	Success was observed for 34/46 (73.9%) patients in the IV group and 38/48 (79.2%) patients in the oral group. 9 IV patients (19.6%) and 5 oral patients (10.4%) were readmitted. There were no significant differences between groups in all-cause mortality.
RCT	Self-administered	13 home	18 inpatients	No significant differences in the duration of treatment or use of antibiotics. Median duration of treatment was 12 days (range 10–24 days) vs. 11 days (range 7–26 days), p = 0.2. No significant difference between groups in improved lung function, p = 0.30. No significant difference in time to next admission between the groups, p = 0.68.

				There were no adverse drug reactions or deaths attributable to the drugs used. There were no differences between groups in IV complication rates, p = 0.57.
Cohort	Self-administered	52 domiciliary IV 23 ESD	36 inpatients	Resolution of infection in 76% of the inpatient group, 80% of the ESD group and 80% of the domiciliary IV group. Thirty-day readmission rates were similar across groups (inpatient 13.8%; ESD 12.5%; domiciliary IV 14.2%). Antibiotic side effects developed in four inpatients (5%), two ESD patients (6.3%) and four domiciliary IV patients (4.7%). No IV access-related complications in the inpatient group, two (6.3%) in the ESD group, and three (3.6%) in the domiciliary IV group. No deaths were recorded in any group.

CI = confidence interval; HR = hazard ratio; ESD = early supported discharge

Table B: efficacy of hospital-based versus home-based intravenous antibiotic therapy in children aged <16[5]

**Individual studies reported multiple outcomes, therefore the same study appears more than once in the table.*

Study type	n patients	Disease/infection	Inpatient care	OPAT	p-value
Treatment failure (as per study definition); 5 studies					
Prospective	16	Appendicitis (post-surgery for rupture)	0	0	-
Retrospective	63	Low-risk febrile neutropenia	0	0	-
Prospective	27	Low risk febrile neutropenia	3/18 (16%)	6/19 (33%)	NR
Prospective	79	Cellulitis (moderate / severe)	7/38 (18%)	2/41 (5%)	0.06

Retrospective	144	Cellulitis	1/103 (2%)	7/41 (7%)	0.30
Resolution of fever (mean number of days); 2 studies					
Retrospective	63	Low risk febrile neutropenia	8.3	7.3	0.06
Prospective	27	Low risk febrile neutropenia	2.4	3.5	0.12
Duration of treatment (mean number of days); 15 studies					
Prospective	26	Cystic fibrosis	18.0	17.0	NS
Retrospective	52	Cystic fibrosis	10.2	15.8	NR
Prospective	16	Appendicitis (post-surgery for rupture)	12.4	11.0	NS
Retrospective	40	Cystic fibrosis	15.9	32.5	<0.001
Prospective	150	Perforated appendicitis	11.2	10.7	NR
Retrospective	63	Low risk febrile neutropenia	6.3	7.6	0.008
Retrospective	50	Cystic fibrosis	16.0	19.0	0.001
Retrospective	375	Cystic fibrosis	12.7	18.9	<0.0001
Retrospective	54	Cystic fibrosis	9.7	16.3	<0.02
Retrospective	117	Cystic fibrosis	12.6	14.4	<0.001
Prospective	27	Low risk febrile neutropenia	4.8	6.3	0.13
Prospective	79	Cellulitis (moderate / severe)	2.3	2.6	0.96
Retrospective	144	Cellulitis	2.7	2.7	0.99
Retrospective	127	Pyelonephritis	3.0	4.5	0.002
Retrospective	44	Meningitis	20.2	15.0	0.19
Readmission after completion of treatment; 6 studies					

Prospective	16	Appendicitis (post-surgery for rupture)	0	0	NR
Prospective	150	Perforated appendicitis	5/98 (5%)	4/52 (8%)	NR
Prospective	79	Cellulitis (moderate / severe)	1/38 (3%)	0/41	0.20
Retrospective	144	Cellulitis	0/103	3/41 (3%)	0.40
Retrospective	127	Pyelonephritis	8/115 (7%)	1/12 (8%)	0.86
Retrospective	44	Meningitis	2/15 (13%)	2/29 (7%)	0.48
Disease complications; 4 studies					
Prospective	16	Appendicitis (post-surgery for rupture)	0/8	0/8	NR
Retrospective	242	Acute appendicitis	3% (wound infection) 2% (intra-abdominal abscess)	1% (wound infection) 2% (intra-abdominal abscess)	NR
Prospective	150	Perforated appendicitis	5/98 (5%)	4/52 (8%)	NR
Retrospective	47	Cystic fibrosis	1/77 (1%)	1/54 (2%)	NS

NA = not applicable; NR = not reported; NS = not significant

Table C: safety of hospital-based versus home-based intravenous antibiotic therapy in children aged <16[5]

Study type	n patients	Disease/infection	Hospital-based events	Home-based events	p-value
Adverse events; 10 studies					
Prospective	26	Cystic fibrosis	0	0	NR
Retrospective	52	Cystic fibrosis	0	0	NR

Prospective	16	Appendicitis (central venous catheter-associated complications)	NA	0	NA
-	36	Cystic fibrosis (drug adverse events)	0	0	NR
Retrospective	47	Cystic fibrosis (drug allergy)	2 (3%)	2 (4%)	NS
Prospective	27	Febrile neutropenia (cefepime-related complications)	0	0	NR
Prospective	27	Febrile neutropenia (outpatient-related complications)	NA	0	NA
-	35	Cystic fibrosis	0	0	NR
Prospective	79	Cellulitis (drug adverse events)	1 (3%)	0	NS
Retrospective	144	Cellulitis (drug allergy)	0	0	NR
Readmission to hospital during treatment; 3 studies					
Prospective	26	Cystic fibrosis	NA	3 (12%)	NR
Prospective	27	Febrile neutropenia	NA	6 (32%)	NR
Prospective	79	Cellulitis	NA	2 (5%)	NR

NA = not applicable; NR = not reported; NS = not significant

Appendix 3: BSAC good practice recommendations 2019

The BSAC good practice recommendations listed in the table below are extracted from the 2019 update[6].

BSAC good practice recommendations
OPAT team and service structure
To ensure patient safety, intravenous antibiotics should be delivered within a formal OPAT service with clear pathways for early hospital discharge or admission avoidance.
The OPAT team should have clear managerial and clinical governance lines of responsibility.
The OPAT team should have an identifiable lead clinician and all OPAT team members should have identified time for OPAT in their job plan.
The OPAT multidisciplinary team should include, as a minimum, a medically qualified clinician (for example an infectious diseases physician or internal medicine specialist), a medically qualified infection specialist (infectious diseases physician or clinical microbiologist), a specialist nurse, and a clinical antimicrobial pharmacist.
A management plan (including use of standardised treatment regimens or specific patient group directions) should be agreed between the OPAT team and the referring team for each patient and this should be documented. This plan should include other relevant specialists and treatment modalities, for example surgical or radiological intervention. It should also state the treatment goal.
OPAT teams should develop local algorithms for novel treatment strategies, for example, longer acting antimicrobials or new infusion devices.
OPAT services should consider the role of telemedicine for supporting suitable patients at home.
Lead clinical responsibility for patients receiving OPAT should be agreed between the referring clinician and the OPAT clinician and documented.
There should be communication between the OPAT team, the patient's general practitioner, the community team (when appropriate) and the referring clinician. As a minimum this should include notification of acceptance onto the OPAT programme, notification of completion of therapy and notification of any further follow-up/management plan post OPAT.
Written communication should be clear, multidisciplinary, and available and accessible to all relevant members of the clinical team at all times, including out of hours.
Patient selection
OPAT should be part of a comprehensive infection and antimicrobial stewardship service, in order to maximise opportunities for identification and selection of suitable patients, and to optimise appropriate management and minimise unintended consequences of antimicrobial therapy.
It is the responsibility of the infection specialist to agree specific infection-related inclusion and exclusion criteria for OPAT. These should incorporate specific infection severity criteria where appropriate.

There should be agreed and documented OPAT patient suitability criteria incorporating physical, social and logistic criteria. These should take into account additional risk factors for treatment failure, for example, co-morbidities and lifestyle issues. These should be documented for each patient.
Initial assessment for OPAT should be performed by a competent member of the OPAT team.
Patients and carers should be fully informed about the nature of OPAT and should be given the opportunity to decline or accept this mode of therapy.
All patients who have been assessed as being at risk of venous thrombosis as inpatients should be considered for further prophylaxis during OPAT if assessed as having ongoing risk.
Antimicrobial management and drug delivery
Oral antimicrobial therapy should always be used in preference to IV therapy where these have equivalent efficacy unless there are other relevant factors, such as toxicity, lack of oral route, allergies, or drug-drug or drug-patient interactions.
The infection treatment plan should be agreed between the OPAT team and the referring clinician before commencement of OPAT.
The treatment plan is the responsibility of the OPAT infection specialist, following discussion with the referring clinician. It should include choice and dose of antimicrobial agent, frequency of administration and duration of therapy and, where appropriate, should take into account flexibility based on clinical response.
Antimicrobial choice within OPAT programmes should be subject to review by the local antimicrobial stewardship programme.
It is the responsibility of the OPAT team to ensure correct and continued prescription of antimicrobials during OPAT, but prescriptions may be written by the referring team under the direction of the OPAT team. Pre-agreed drug choice and dosage for certain conditions (for example soft tissue infection in the context of a patient group direction) is acceptable.
It is the responsibility of the OPAT team to advise on appropriate follow-up for toxicity, compliance and outcome monitoring for those patients recommended by the OPAT team to receive complex oral antibiotic regimens in place of IV therapy. Follow-up of such patients may be best addressed in the immediate post-discharge phase through existing multi-disciplinary OPAT services.
Prescribing for individuals within OPAT should be assessed by an antimicrobial pharmacist.
Storage, reconstitution and administration of antimicrobials must comply with published Royal Pharmaceutical Society/Royal College of Nursing standards and with local hospital clinical pharmacy standards.
The OPAT team, in collaboration with the referring team, is responsible for the choice of intravascular access for each patient.
Insertion and care of the intravascular access device must comply with published Royal College of Nursing standards, and with local and national infection prevention and control guidance.

A member of the OPAT team with the appropriate competencies is responsible for selection of the drug delivery device; use of these must comply with published Royal College of Nursing standards and local hospital guidelines.
Antimicrobial agents should only be used in pumps or elastomeric devices if there are robust drug stability data meeting the standards of the NHS 'Standard Protocol for Deriving and Assessment of Stability'.
Training of patients or carers in the administration of IV medicines must comply with published Royal College of Nursing standards and should be carried out by a member of the OPAT team with the relevant competencies. Both the OPAT nurse specialist and the patient/carer must be satisfied of competence and this should be documented.
All administered doses of IV antimicrobial therapy should be documented on a medication card or equivalent, including doses administered out of hospital.
The first dose of a new antimicrobial should be administered in a supervised setting. This may be the patient's own home if the antimicrobial is administered by a person competent and equipped to identify and manage anaphylaxis.
Monitoring of the patient during OPAT
Patients with skin and soft tissue infections should be reviewed daily by the OPAT team to optimise speed of IV to oral switch.
There should be a weekly multidisciplinary meeting/virtual ward round, including as a minimum the OPAT specialist nurse, OPAT physician, medical infection specialist, and antimicrobial pharmacist, to discuss progress (including safety monitoring and outcome) of patients receiving OPAT.
Patients receiving in excess of one week of antimicrobial therapy should be regularly reviewed by a member of the OPAT team, in addition to discussion at the weekly multi-disciplinary team meeting. The frequency and type of review should be agreed locally.
Patients should have blood tests performed at least weekly. Blood tests should include full blood count, renal and liver function, C-reactive protein (CRP) and therapeutic drug monitoring where appropriate. Other tests may be required for specific indications or therapies.
The OPAT team is responsible for monitoring clinical response to antimicrobial management and blood investigations, and for reviewing the treatment plan, in conjunction/consultation with the referring specialist as necessary.
There should be a mechanism in place for urgent discussion and review of emergent clinical problems during therapy according to clinical need. There should be a clear pathway for 24-hour immediate access to advice/review/admission for OPAT patients and this should be communicated to the patient both verbally and in writing.
Outcome monitoring and clinical governance
Data on OPAT patients should be recorded prospectively for service improvement and quality assurance including auditing and benchmarking. A local database would facilitate this process. This

information should be shared with all relevant stakeholders, including referring clinicians and general practitioners and may contribute to a national registry.
Standard outcome criteria should be used on completion of IV therapy and these should relate to patient-specific aims of therapy. Data on readmissions, death during OPAT, adverse drug reactions, vascular access complications and healthcare-associated infections, should also be recorded.
Risk assessment and audit of individual processes (particularly new processes) should be undertaken as part of the local clinical governance programme.
Regular surveys of patient experience should be undertaken in key patient groups, such as short- and longer-term treatment groups.
There should be an annual review of the service to ensure compliance with national recommendations.
Each member of the OPAT team is responsible for personal continuing professional development relating to best clinical practice.

Appendix 4: additional data tables for economics work

Table A: infection categories breakdown

Infection category	Infection included in this category
Skin and soft tissue infections	Cellulitis
	Other
Orthopaedic infections	Prosthetic joint infection (knee)
	Osteomyelitis - native
	Prosthetic joint infection (hip)
	Osteomyelitis - surgically related
	Discitis/vertebral osteomyelitis
	Prosthetic joint infection (other)
	Discitis/vertebral osteomyelitis - device related
	Osteomyelitis (other)
Diabetic foot infections	Osteomyelitis - diabetic foot
	Diabetic foot infection - no osteomyelitis
Complex urinary tract infections	Urinary tract infections
Bronchiectasis	Bronchiectasis
	Respiratory tract infections
Intra-abdominal infections	Gastro-intestinal infections
	Hepatic abscess
	Pelvic abscess

Table B: Condition-specific type and distribution of antimicrobial medicines in OPAT (clinical expert opinion)

Condition	Medication	Distribution
SSTI (IV)	Ceftriaxone	75%
	Teicoplanin	10%
	Daptomycin	5%
	Flucloxacillin	5%
	Dalbavancin	5%
Bone-Joint (IV)	Ceftriaxone	60%
	Teicoplanin	30%
	Ertapenem	10%
Bone-Joint (oral)	Ciprofloxacin/Rifampicin	25%
	Levofloxacin/Rifampicin	12.5%
	Co-trimoxazole/Rifampicin	12.5%
	Clindamycin/Rifampicin	12.5%

	Linezolid/Ciprofloxacin	12.5%
	Linezolid	25%
Diabetic foot (IV)	Ceftriaxone	45%
	Teicoplanin	10%
	Ertapenem	45%
Diabetic foot (oral)	Clindamycin/Doxycycline	25%
	Clindamycin/Co-trimoxazole	12.5%
	Clindamycin/Ciprofloxacin	12.5%
	Linezolid/Ciprofloxacin	12.5%
	Ciprofloxacin/Doxycycline	25%
	Levofloxacin/Doxycycline	12.5%
Complex UTI (IV)	Ertapenem	90%
	Temocillin	10%
Bronchiectasis (IV)	Ceftazidime	70%
	Piperacillin with tazobactam	15%
	Meropenem	15%
Intra-abdominal (IV)	Ertapenem	75%
	Piperacillin with tazobactam	25%

IV = intravenous

Table C: cost and dosage of OPAT antimicrobial medicines (IV) as listed in the BNF 2020

Medicines (IV)	Dose in OPAT	Frequency of administration	Cost per pack*
Ceftriaxone	2g	Once daily	£19.18
Teicoplanin	600mg	Once daily or 1200mg 3 times per week	£3.93
Daptomycin	700mg	Once daily	£60.00
Flucloxacillin	8g	24-hour infusion	£6.00
Dalbavancin	1g	One-off	£558.70
Ertapenem	1g	Once daily	£31.65
Temocillin	2g	Every 12 hours	£25.45
Ceftazidime	2g	Three times per day	£17.59
Piperacillin with tazobactam	4.5g/18g	Four times per day/24-hour infusion	£76.50
Meropenem	1g	0.5g-1g every 8 hours	£186.70

IV = intravenous; BNF = British National Formulary

**cost per cheapest pack, dose per pack differs from dose in OPAT*

Table D: cost and dosage of OPAT antimicrobial medicines (oral) as listed in the BNF 2020

Medicines (oral)	Dose in OPAT	Frequency of administration	Cost per pack*
Ciprofloxacin	750mg	Every 12 hours	£8.00
Levofloxacin	500mg	Every 12 hours	£24.50
Co-trimoxazole	960mg	Every 12 hours	£23.48
Clindamycin	600mg	Every 8 hours	£38.23
Linezolid	600mg	Every 12 hours	£7.48
Doxycycline	100mg	Every 12 hours	£1.64
Rifampicin	400mg	Every 12 hours	£123.60
Rifampicin	50mg	Every 12 hours	£54.69

BNF = British National Formulary

**cost per cheapest pack, dose per pack differs from dose in OPAT*

Table E: NHS England reference cost for inpatient stay – healthcare resource group codes and descriptions

Condition	HRG code	Description
SSTI	HD21 D-H	Soft tissue disorders with CC score 0-12+
Orthopaedic / Diabetic foot infections	HD25 D-H	Infections of bones or joints with CC score 13+
	HE81 A-C	Infection or inflammatory reaction, due to, internal orthopaedic prosthetic devices, implants or grafts, with CC score 0-13+
Complex UTI	LA04 N-S	Kidney or urinary tract infections, without interventions, with CC score 0-13+
Bronchiectasis	DZ23 M-N	Bronchopneumonia without interventions, with CC score 0-10
Intra-abdominal	FD01 F-J	Gastrointestinal infections without interventions, with CC score 8+

SSTI = skin and soft tissue infections; HRG = healthcare resource group

Table F: summary of cost-minimisation model assumptions

No	Assumption	Source/justification
1	All patients with long term infections are assessed on admission and upon discharge by a specialist consultant. Patients spend 30 minutes with a specialist consultant and 1 hour with a nurse at initial and final assessment.	BSAC good practice recommendations (3.1-3.15); communication with clinical experts.
2	Skin and soft tissue infections are a nurse-led condition unless the patient is treated with dalbavancin.	BSAC good practice recommendations (3.1-3.15); communication with clinical experts.
3	All patients with complex UTI are assessed by a consultant once.	BSAC good practice recommendations (3.1-3.15); communication with clinical experts.

4	All patients are allocated 15 minutes of pharmacist time per treatment episode.	BSAC good practice recommendations (3.1-3.15); communication with clinical experts.
5	Laboratory tests including UE, LFT, FBC, c-reactive protein, are done at initial and final assessment and once weekly for longer-term infections. Patients treated with teicoplanin receive weekly teicoplanin level blood tests.	BSAC good practice recommendations (4.4); communication with clinical experts. Type of tests might vary with the choice of antimicrobial.
6	All patients requiring longer-term treatment (more than 7 days) are assessed weekly at an MDT meeting. This is approximately 5 minutes of consultant, pharmacist and specialist nurse time per patient.	BSAC good practice recommendations (4.2); communication with clinical experts.
7	Each daily visit to an outpatient clinic lasts 40 minutes, during which a band 6 nurse examines the patient, prepares and administers medication. A nurse visiting the patient's home would spend the equivalent amount of time.	Communication with clinical experts. This might be a conservative approach given that some antimicrobials are administered in 2-3 minutes.
8	Patients with infections requiring longer-term treatment who self-administer, visit the clinic once weekly for a check-up with a nurse and to have their blood work done.	BSAC good practice recommendations (4.3); assumption.
9	Patients who self-administer with bolus IV receive three training sessions with a nurse (50:50 split band 5/band 6), each lasting 1 hour. Patients who self-administer with an elastomeric device receive one training session.	Communication with clinical experts; assumption; BSAC good practice recommendations (3.13).
10	Single-use elastomeric devices administered in an outpatient setting are filled by hospital staff (approximately 15 minutes of nurse's time).	Assumption; clinical expert opinion.
11	Single-use elastomeric devices used for self-administration are commercially pre-filled.	Assumption; clinical expert opinion.
12	Consumables: Each patient receives one PICC line. Per administration each patient receives: one apron, one pair of gloves, four needles, four syringes, one pre-injection swab, three 0.9% sodium chloride ampoules.	Communication with clinical experts; assumption. Varies with method of administration.

13	A nurse travelling to the patient's home would spend 33 minutes (non-patient contact time) per journey travelling with an ambulance car (£10.63 per journey).	ISD Cost book for Scotland. This is an approximation due to lack of available data for distances travelled in OPAT. Distance travelled varies with geographic location. Longer distances might be travelled in the highlands and islands in Scotland. It was assumed that this estimate for Scotland is relevant to the whole of the UK.
14	Type and distribution of medicines for each condition in the analysis are based on clinical expert opinion	NORS data do not link conditions to antimicrobials.
15	Cost of linezolid comes from eMIT; all other costs of antimicrobials come from the BNF (cheapest tariff).	A generic version of linezolid is used in OPAT but this is not reflected in the BNF cost which is substantially higher.
16	Antimicrobials requiring more than once daily administration (temocillin, ceftazidime, meropenem and piperacillin with tazobactam) are assumed to be self-administered (bolus IV) only.	More than once daily visits (hospital or nurse home visit) in OPAT are not options in clinical practice.
17	Only piperacillin with tazobactam, flucloxacillin, and ceftriaxone are administered with elastomeric devices in the six infection types included in the analysis.	BSAC good practice recommendations (3.12); clinical expert opinion.
18	For bronchiectasis patients can travel daily to outpatient clinic for piperacillin with tazobactam (with buffered saline) to be administered as continuous IV with elastomeric device. Although the same model of care is available for piperacillin with tazobactam for the treatment of intra-abdominal infections, for simplicity only ertapenem was assumed to be used if patients attended an outpatient clinic daily.	An assumption was made that if a patient attends the OPAT clinic daily or is visited by a nurse, the cheapest treatment option would be used in clinical practice. In the case of treating intra-abdominal infections, ertapenem once daily is cheaper than continuous piperacillin with tazobactam administered via an elastomeric device. In patients with bronchiectasis, continuous piperacillin with tazobactam through an elastomeric device is the only treatment option in the hospital or nurse daily visits OPAT service delivery models.

19	The cost of elastomeric devices is based on the average cost of two commercially available devices assuming equal market share.	BSAC good practice recommendations (3.12); clinical expert opinion.
20	A patient would spend the equivalent amount of time in hospital in the absence of OPAT.	Clinical expert opinion.
21	Condition-specific HRG cost per excess bed-day in hospital was used to estimate the cost of inpatient stay.	The true cost per day of an inpatient stay for patients who are eligible for OPAT is unknown. NHS England reference costs are considered a standard source of cost estimates associated with certain diagnoses or interventions. Costs are presented as per episode of average treatment duration and cost of excess bed-days if treatment goes beyond the expected treatment duration (trim point). Due to lack of better evidence, excess bed-day costs were considered the best source of costs for inpatient stay for the purposes of this analysis. Condition-specific costs were selected to allow for granularity. Costs were similar so assuming the same cost for each condition is also a reasonable assumption.

BSAC = British Society for Antimicrobial Chemotherapy; UTI = urinary tract infections; UE = urea and electrolytes; LFT = liver function test; FBC = full blood count; MDT = multi-disciplinary team; IV = intravenous; CIVI = continuous intravenous infusion; ISD = information services division; PICC = peripherally inserted central catheter; HRG = healthcare resource group; eMIT = electronic market information tool; BNF = British National Formulary

Table G: total costs of models of care and savings associated with OPAT across all infection types over 5 years

Model of care	Total costs	Total savings (OPAT)
Inpatient stay	£103,070,256	
OPAT once daily outpatient clinic visits*	£33,014,148	£70,056,108
OPAT nurse home visits	£43,333,446	£59,736,809
OPAT self-administration (bolus IV)	£26,421,799	£76,648,457
OPAT self-administration (elastomeric device)**	£31,502,516	£67,578,565

bronchiectasis excluded;complex urinary tract infections excluded; OPAT = outpatient parenteral antimicrobial therapy, IV = intravenous;*