

## Current approach and methods

Víctor José González Ramallo<sup>1</sup>  
Manuel Mirón Rubio<sup>2</sup>  
Oriol Estrada Cuxart<sup>3</sup>  
María Eugenia García Leoni<sup>1</sup>

# Usefulness of Hospital at Home in nosocomial infections: advantages and limitations

<sup>1</sup>Unidad de Hospitalización a Domicilio, Hospital General Universitario Gregorio Marañón. Madrid. Spain

<sup>2</sup>Servicio de Hospitalización a Domicilio, Hospital Universitario de Torrejón. Torrejón de Ardoz (Madrid). Spain.

<sup>3</sup>Dirección Asistencial, Hospital Germans Trias i Pujol. Badalona (Barcelona). Spain

### ABSTRACT

Hospital at Home units allows ambulatory treatment and monitoring of complex and serious infections. Nosocomial infections produce an extension of the stay in hospital often specifying long intravenous treatments without any effective oral alternatives. Daily dosing of antimicrobial are easier to administer at home. The use of portable programmable pump infusion and elastomeric devices allow efficient and safe infusions for most antimicrobials at home. Some antibiotics against multidrug-resistant organisms of recent introduction have a suitable profile for outpatient intravenous treatment.

**Key words:** Hospital at Home, OPAT, nosocomial infections

### Utilidad de la Hospitalización a Domicilio en las infecciones nosocomiales: ventajas y limitaciones

### RESUMEN

Las unidades de Hospitalización a Domicilio permiten el tratamiento y control ambulatorio de infecciones graves y complejas. Las infecciones nosocomiales suponen una prolongación de la estancia hospitalaria precisando con frecuencia largos tratamientos intravenosos sin alternativa eficaz oral. Los antimicrobianos más sencillos de administrar en domicilio son aquellos con dosis única diaria. La utilización de bombas programables portátiles de infusión y de dispositivos elastoméricos permite infundir con eficacia y seguridad la mayoría de antimicrobianos. Algunos de los antibióticos frente a microorganismos multirresistentes de reciente introducción tienen un perfil muy adecuado para el tratamiento intravenoso ambulatorio.

**Palabras clave:** Hospitalización a Domicilio, TADE, infección nosocomial

Correspondence:  
Víctor José González Ramallo  
Unidad de Hospitalización a Domicilio, Hospital General Universitario Gregorio Marañón.  
Madrid. Spain  
E-mail:

### HOSPITAL AT HOME

Hospital at Home (HaH) is a care modality that allows the care, at home, of patients with acute processes or decompensation of their chronic pathology when they require complex care and treatment suitable to inhospital supervision. If not for this service, these patients should have to remain hospitalized<sup>1</sup>.

In recent years a growing number of relevant articles have been published which have increased the level of evidence displaying the advantages of HaH. Compared with conventional hospitalization, we can clearly say that HaH obtains clinical results not inferior to those of the hospital and that it is indeed a safe alternative for suitably selected patients<sup>2</sup>.

In a meta-analysis study conducted by Caplan on 62 randomized clinical trials in HaH, it was concluded that clinical efficacy and safety are equivalent to those of patients admitted to a hospital facility. Of the 34 studies in which a cost study was carried out, 32 showed lower costs in HaH, with an estimated average saving of 26.5%. Significant reductions in mortality and re-entry rates were also found. In 22 trials, the satisfaction of patients and caregivers treated at home was analysed, being higher in HaH in 21 of them. No appreciable changes were found regarding the caregiver's overload<sup>3</sup>.

Despite these beneficial aspects, the HaH faces a number of constraints stemming both from its insufficient development and virtually no planning. The diversity of care models is striking. In some cases, the HaH units deal with processes that could be performed by primary care teams or other levels of care. This heterogeneity of models hinders the generalization of HaH and its correct evaluation in Spain and its extension to other European countries.

Its implantation in Spain is irregular. According to recently reported data<sup>4</sup> by the Spanish Society for Home Hospitalization (SEHAD), only one out of every 7 acute hospitals in Spain has a HaH unit and only 48% of those units offer

coverage to all of their reference population. The proportion of hospital beds is 2.3 / 103 inhabitants, while the available places of HaH are 0.08 / 103 inhabitants. That is for every 30-hospital beds, there is only one square of HaH. Regarding the overall hospitalization episodes in Spain in 2013 (3,979,900), only 2% were treated in HaH. The situation is worse in other European countries where this care alternative is not even implemented.

HaH is particularly effective in the management of some problems that pose a growing threat to hospital sustainability, such as nosocomial infections or complex chronic patients with frequent hospital admissions. It is a flexible service with the capacity to adapt to the needs of each centre. There are several crucial factors involved in the success of a HaH unit: having an expert team and sufficient means to perform complex care at home and appropriate patient selection<sup>5</sup>.

#### OUTPATIENT PARENTERAL ANTIMICROBIAL THERAPY

Outpatient parenteral antimicrobial therapy (OPAT) consists on administering through intravenous, intramuscular or subcutaneous routes two or more doses of an antimicrobial on different days, to non-hospitalized patients, ie not staying overnight in the hospital<sup>6</sup>. The OPAT includes administration anywhere, as long as the patient is not admitted to a hospital. Thus, apart from the home, antimicrobials can be administered on an outpatient whose care is taking place in day hospitals, outpatient clinics, emergency services, primary care centres, nursing homes or infusion centres<sup>7</sup>.

In Spain OPAT is usually performed by HaH units<sup>8,9</sup>. These are healthcare structures dependent on the hospitals from which they draw both their human and material resources<sup>1</sup>. It is very important that the medical and nursing staff that integrate these units have a specialized training that allows them to provide comprehensive care to the infected patient. OPAT should not be an isolated procedure and must be inserted in a set of diagnostic, therapeutic, preventive and health education activities<sup>8</sup>. In other countries, especially in the United States, due to the high costs of medical visits, OPAT activity is fundamentally based on nursing. This less medicalized care scheme has fewer guarantees, especially in complex<sup>10</sup> or pluri-pathological patients, than the one based on HaH units.

**Selection process for OPAT.** The safety and efficacy of OPAT depends on the correct selection of the patient and its infectious process, the prescribed antimicrobial agents, the venous access route and the infusion devices and modalities. Prior to the decision on each of these aspects should be clearly established the need to use the intravenous route to treat the infectious process.

**Table 1** Stability after reconstitution of different antimicrobial agents that required more than once a day dosing.

ANTIBIOTIC	CONCENTRATION	5° C	25° C
Ampicillin	10-30 mg/mL	48 h	8-24 h
Amoxicillin/clavulanate	5-20 mg/mL	8 h	4 h
Cloxacillin	20 mg/mL	21 d	24 h
Cefepime	1-40 mg/mL	7 d	12-24 h
Ceftaroline*	12 mg/mL	24 h	6 h
Ceftazidime	1-40 mg/mL	21 d	12-48 h
Ceftazidime/avibactam*	40/10 mg/mL	24 h	12 h
Ceftolozane/tazobactam*	10/5 mg/mL	7 d	24 h
Doripenem	5-10 mg/mL	7 d	4-24 h
Meropenem	1-20 mg/mL	2448 h	6 h
Piperacillin/tazobactam	100-150 mg/mL	48 h	24 h
Vancomycin	5 mg/mL	7 d	24 h

\* Recently introduced. Limited experience. h = hours; d = days

**Patient selection.** Not all patients are candidates to be treated on an outpatient basis. From the clinical point of view, a diagnosis of certainty, clinical stability and absence of comorbidity with intrinsic indication of hospital admission are required. Requests for patients residing outside the geographical coverage area of the HaH unit should be rejected and also if adequate human, material and organizational resources are not available and appropriate to each case needs. The existence of a trained caregiver, the hygienic conditions of the home and the availability of telephone communication are necessary requirements to guarantee the quality and safety of health care.

Exclusion criteria for OPAT generally include active addiction to intravenous drugs, acute psychosis, suicidal ideation, indigence, habitual lack of light and running water, and inability to collaborate when necessary or to understand the risks of the procedure.

**Selection of infectious process.** The commercialization of new antimicrobials with a better safety profile and more convenient dosing<sup>11,12</sup> and the existence of increasingly versatile infusion devices allow us to affirm that almost any infectious process is susceptible to be treated in HaH units. Limitations are determined by patient conditions and the availability of resources.

In addition, the number of cases attended to at the home without a previous period of hospitalization is increasing<sup>13</sup>. Despite the positive effect of this strategy on saving hospital stays, infections with high risk of serious complications should be admitted to the hospital as a step prior to home treatment. This category includes, among others, endocarditis<sup>14,15</sup>, meningitis and severe sepsis of any aetiology.

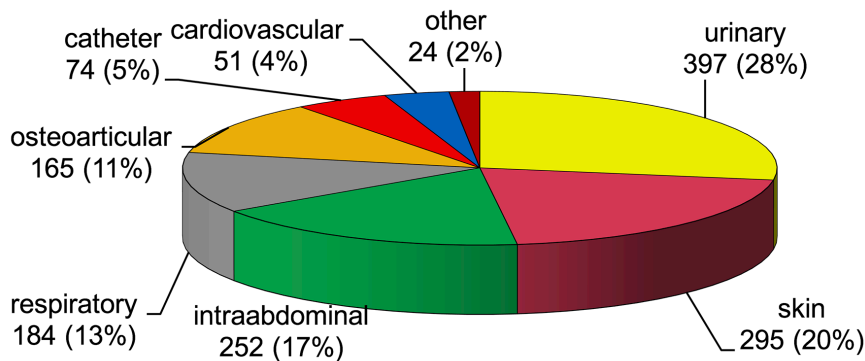


Figure 1 Type of nosocomial infections treated in Hospital at Home Units of Spain. Data from the TADE Registry.

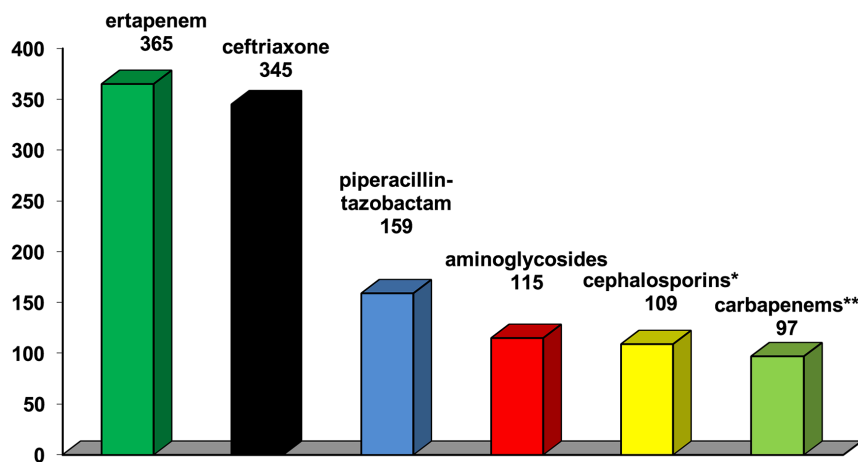


Figure 2 Antimicrobials mainly used in nosocomial infections by the HaH units in Spain. Data from the TADE Registry.

\* Ceftriaxone excluded

\*\* Ertapenem excluded

**Antimicrobial selection.** In the selection of the most appropriate antimicrobial for OPAT, it is necessary to consider the type of infection, the drug physicochemical characteristics, dosage, safety profile, infusion time, type of venous access, patient preferences and, in the case of needing their collaboration, the capacity of understanding and the ability of the caregiver.

Classically it has been considered as an ideal antibiotic if it combines a good safety profile, activity spectrum that allows the use in monotherapy, administration in single daily dose, brief time infusion, low cost and the possibility of intramuscular administration<sup>16</sup>. Drugs that require more than one daily dose and are stable at room temperature for 24 hours once diluted (table 1) can be administered with programmable electronic devices<sup>17</sup>. When they are not stable, self-administration can be used with

pre-filled and refrigerated elastomeric pumps<sup>18</sup>, or by gravity.

**Venous access selection.** The main factors influencing the choice of catheter and the insertion site are the characteristics of the drug, the duration of treatment and the patient's preferences. In general, thick-gauge (central or peripheral catheter) veins should be channelled when drugs with high irritant potential (ampicillin, cloxacillin, and doxycycline) are administered, when extravasation can lead to tissue necrosis (acyclovir) and prolonged treatments. Whenever possible it must be taken into consideration the patient's opinion for catheter location.

**Selecting the mode and infusion device.** At home, four infusion modalities are used: direct intravenous, gravity, infusion with electronic pumps, and infusion with elastomeric pumps, each option with its advantages and limitations.

**Indications.** Early OPAT experiences focused on infections requiring long-term parenteral antibiotic treatment and which in turn did not represent imminent vital risk. Examples of these indications were osteomyelitis<sup>19</sup> and septic arthritis, soft tissue infections, respiratory infections in patients with cystic fibrosis, etc. The spectrum

of infections for OPAT was progressively expanded by its safety and favourable clinical results<sup>20, 21</sup>.

The emergence of more effective, safe and long-lasting antibiotics and the availability of improved infusion equipment have allowed this expansion. At present, practically any infection can be treated in the outpatient setting if the patient's clinical conditions allow it and if there are enough qualified assistance teams. New antimicrobials such as ceftolozano/tazobactam, dalbavancin or tedizolid are very suitable for OPAT.

## OPAT IN NOSOCOMIAL INFECTIONS

There is little information about the safety and effectiveness of OPAT in infections acquired in acute care hospitals. Some studies have analysed it in infections caused by multi-drug resistant microorganism, irrespective of the place of acquisition. In a prospective observational study carried out in a

**Table 2** Percentage of multi-resistant microorganisms from nosocomial vs. community acquired infections treated in HaH units in Spain. Data from the TADE Registry.

MICROORGANISM	NOSOCOMIAL (n = 1442)	COMMUNITY (n = 6023)	p value
<i>Staphylococcus</i> MR	112/199 (56.2%)	112/349 (32%)	< 0.001
<i>S. aureus</i> MR	39/97 (40.2%)	77/248 (31%)	0.10
<i>S. coagulase</i> negative MR	73/102 (71.5%)	35/101 (34.6%)	< 0.001
<i>Escherichia coli</i> ESBL	146/283 (51.6%)	417/1339 (31.1%)	< 0.001
<i>Klebsiella pneumoniae</i> ESBL	98/150 (65.3%)	124/258 (48%)	< 0.001

HaH: Hospital at Home; MR = methicillin-resistant; ESBL: extended spectrum beta-lactamase

Spanish Hospital at Home Unit during 2008-2012 period, 433 infections caused by multidrug resistant bacteria were treated intravenously at home<sup>22</sup>. The antibiotic drugs were administered either by caretakers or were self-administered by patients with elastomeric devices. 79% of these infections were health-associated without distinction between acute hospital or other place acquisition. Hospital readmissions were uncommon, but there were increased readmissions in the case of enterococcal and/or healthcare-associated infections.

We have used the episodes included during the first five years (2011-2016) of the TADE Registry in which we collected the OPAT treatments performed at more than thirty Spanish HaH units, in order to analyse the characteristics of nosocomial acquisition infections by comparing them with community acquired.

Of the 9,314 OPAT episodes included, 1,463 (16%) were acquired in an acute hospital (group N) and 7,063 (76%) in the community (group C). The mean/average age of the N group (67.6; range 11-100) was not different from that of the C group (66.7; range 2-107), with males predominating in both groups (64.1% vs 55.7%). The Charlson index was significantly higher in the N group ( $3.2 \pm 2.3$  vs  $2.3 \pm 2.2$ ).

The most frequent sites of nosocomial infection were urinary (28%), cutaneous (20%) and intraabdominal (17%) (figure 1), while in the community they were urinary (35%), respiratory and cutaneous (13%). In group N, 74 episodes (5%) of intravascular catheter-associated infection were treated.

The most frequent causative microorganisms in the N group were *Escherichia coli* (19.3%), *Pseudomonas* (14.8%), *Staphylococcus* (13.6%) and *Klebsiella* (11%), while in C they were *E. coli* (22.2%), *Pseudomonas* (14.2%), *Staphylococcus* (5.7%) and *Streptococcus* (5.4%). The percentage of methicillin-resistant *Staphylococcus* was greater in group N (56.2% vs 32%). The percentage of ESBL-bearing Enterobacteriaceae was *Escherichia* (51.6% vs 31%) and *Klebsiella* (60.8% vs 42.3%) (table 2).

In figure 2 we show the antimicrobials most used in group N (figure 2). Electronic infusion pumps (27.6%) or elastomeric devices (22%) had to be used in a similar percentage in both groups. Self-administration was used in 17% of cases without

differences between groups.

The duration of OPAT was similar in both groups (9.4 vs 9.8 days) with previous stay in conventional upper hospitalization in N (15 vs 5.5 days). A total of 117 patients (8.1%) from the N group and 263 (4.3%) from the C group were required for non-scheduled rehospitalization, and 13 patients in the N group (0.9%) and 87 (1.4%) in the C died.

These results suggest that despite the greater comorbidity of patients and the presence of more multi-resistant microorganisms, HaH units are an effective and safe care tool for the treatment of nosocomial infections.

The general advantages advocated for HaH assistance are especially evident when used for OPAT. In a recent economic study carried out in three Spanish centres<sup>23</sup> the economic savings obtained with the use of OPAT in HaH compared to maintenance in conventional hospitalization was higher than 80% for each stay. This saving is much higher than that reported for other non-infectious HaH indications (ie, chronic diseases, palliative care).

The hospital gains an additional advantage by not needing to block beds or use other measures to avoid the transmission of nosocomial infection that is frequently produced by multi-resistant microorganisms that require isolation.

## CONCLUSIONS

HaH is an effective and safe alternative in the treatment of nosocomial infections through OPAT. It also has both clinical advantages and perceived quality for the patient as well as costs and avoiding problems created by isolation for the hospital.

At present the type of antimicrobial is not a limitation for the realization of OPAT, being able to be administered in the great majority, in ambulatory form. The participation of the patient and their caregivers in the infusion process is a booming practice that facilitates the administration of complex treatments.

The main limitations to the practice of OPAT are restricted to the clinical instability of the patient and the absence of adequate social conditions in the home.

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