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SUSTAINABLE PRACTICE

Sustainable practice: Prescribing oral over intravenous medications

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What you need to know

- The carbon footprint of manufacturing, using, and disposing of intravenous medications and their packaging is likely to be higher than for oral medication
- Consider prescribing oral medications whenever intravenous therapy would be unlikely to be more beneficial than oral preparations
- Tools to support switching of intravenous to oral medications can help to improve practice at a systems level

Oral medication can often be prescribed instead of intravenous options. Switching intravenous to oral administration can help to reduce the carbon footprint of clinical care, and has clinical, resource, and cost benefits. This article outlines the environmental benefits of oral over intravenous medications, and offers pointers on how to safely embed appropriate prescribing and intravenous to oral switches (IVOS) into clinical practice.

Why change is needed

Overuse of intravenous medicines when oral formulations would be more appropriate is a global phenomenon, according to the World Health Organization.[1] Intravenous medicines are associated with a higher rate of bloodstream and catheter related infections, require more nursing resources to administer, and are less comfortable for patients than oral equivalents. They are also more expensive (both for the medication and for the equipment required for administration).[2]

The carbon footprint of the manufacture and disposal of packaging is likely to be greater for all intravenous medications compared with their oral forms. Based on UK emissions data, one estimate of the carbon footprint of oral and intravenous paracetamol found that 1 g oral paracetamol (0.003 kg CO_2e) used in the perioperative period had a 68-fold lower carbon footprint than 1 g intravenous paracetamol in glass packaging (0.193 kg CO_2e) and a 45-fold lower footprint than 1 g intravenous paracetamol in plastic packaging (0.130 kg CO_2e).[3] These estimates did not account for other aspects of the life cycle of medications, such as transport, storage, use, manufacture of the medication itself, or for the carbon footprint of the equipment used to administer intravenous medications (eg, giving sets, non-sterile gloves, alcohol swabs, cannulas, and cannula dressings); therefore the differences in environmental impact of intravenous versus oral are probably underestimated. The carbon footprint of equipment for administration can be significant. A quality improvement project reducing unnecessary cannulation in one emergency department in England saved £125 000 and >24 000 kg CO_2e per year, equivalent to more than 300 outpatient appointments for acute care.[4,5]

The environmental footprint and financial cost of intravenous medication is even greater when multi-dose medications require dilution with packaged diluents and specialised administration methods such as continuous infusion pumps or in-line filters (eg, for administration of intravenous phenytoin). Additionally, single use plastics associated with intravenous medication administration add to our worsening pollution problem.[6] From a patient's perspective, giving medications intravenously rather than orally is associated with increased risk of line related infections, permanent disability or disfigurement if extravasation and/or cannula site infection occur, reduced ability to mobilise independently, delayed hospital discharge, and discomfort from cannulation.[7-9]

Evidence for the solution

Studies of bioavailability and a small number of randomised controlled trials show that converting to oral medications is often as effective as continuing on with intravenous medications.[1] The OVIVA trial, conducted across 26 centres in the UK with 1015 participants, showed that for patients with complex orthopaedic infections, oral antibiotics were non-inferior to intravenous antibiotics.[10] When intravenous therapy is recommended for six weeks, this can safely be switched to oral therapy in the first week of treatment, or in the first week after surgery if it occurred.

Accurate assessment of when to consider intravenous to oral switches can be challenging for clinicians, and considerable variation in practice exists.[11] When protocols have been developed to support clinicians considering IVOS, this can lead to reductions in intravenous therapy. For example, in a prospective quasi-interventional study in a hospital in Saudi Arabia, pharmacists offered physicians' recommendations on whether a switch from intravenous to oral might be considered. Switches to intravenous medications were made in 60.7% of the 677 switch recommendations, with no effect on re-admission rates or mortality.[12]

What you can do

We recommend three actions that prescribers can take to improve the appropriateness of intravenous

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and oral prescriptions and reduce medicines' negative environmental impacts.

1. Consider oral instead of intravenous medications when clinically appropriate

Select the oral route to initiate medicines as long as the patient can tolerate oral medication at the required dose, and intravenous therapy would not be expected to extend clinical benefit.

The decision to prescribe oral medications depends on patient factors such as presence of vomiting, malabsorption, dysphagia (which affect pharmacokinetics), and ability to adhere to dosing (for example, if the person is confused). For antimicrobials, consider the characteristics of the infection, including site of infection and clinical progression as assessed by factors such as systemic features and inflammatory markers.

2. Timely review of intravenous medication

Review intravenous medicines for oral switch in a timely manner. For antimicrobials, this is already part of established antimicrobial stewardship protocols and programmes.[15]

An intravenous-to-oral switch may not always involve the same medication being given in oral form. In particular, where a medication that is being administered intravenously has little or no oral bioavailability, an alternative medication that has the required therapeutic properties and sufficient oral bioavailability may be considered. For example, many antibiotics, including gentamicin and cefotaxime, are not absorbed orally but can be switched to alternative agents. Some examples of medications with high oral bioavailability are outlined in table 1.

Table 1 | Selected medications with high oral bioavailability, which may be considered for intravenous to oral switch[1 2 13 14]

Medication	Bioavailability according to electronic medicines compendium (https://www.medicines.org.uk/emc)	Bioavailability according to drugbank online (https://go.drugbank.com)
Amoxicillin	70%	60%
Digoxin	63% (tablet form) 75% (oral solution)	50-100%
Doxycycline	"virtually completely absorbed after oral administration" No percentage provided	73-95%
Esomeprazole	64% after a single dose, 89% after repeated once daily administration	64% after a single dose, approximately 90% after repeated once daily administration
Fluconazole	Over 90%	Over 90%
Levetiracetam	Close to 100%	Essentially 100%
Levofloxacin	99-100%	99%
Metronidazole	"Almost completely absorbed"	Greater than 90%
Paracetamol	"Readily absorbed"	88%
Voriconazole	96%	96%

3. Offer education and training to support the multidisciplinary team

Health professionals can contribute to system changes locally, regionally, and nationally that prioritise use of oral over intravenous medication where appropriate. IVOS tools, such as the one developed by UK Health Security Agency,[16] are guides to help clinicians identify which patients can be considered for a switch from intravenous to oral antibiotics.

IVOS decision aids could potentially be adapted to guide clinicians in prescribing medications other than antimicrobials and could be accessible to patients to support shared decision making about intravenous to oral medication when appropriate. The creation of intravenous-to-oral medications checklists or computer generated reminders for switch may support staff engagement.[12] Clinical leaders can train clinicians so that they are made aware of their local IVOS protocol and its rationale. Multi-professional education can enhance clinicians' understanding of biases that can affect decision making and the importance of effective discussion and collaboration to provide best patient care.

A patient's perspective

My experiences of being in hospital have been shaped significantly by the intravenous drip and the cannula in my hand. Not being able to walk around or use my arm to hold my baby after birth had a big impact. The differences between this and my experience of oral antibiotics have been memorable. I would prefer to be moved onto oral antibiotics at the soonest possible time for this reason, and it would also help me to know that this was better for the environment.

Education into practice

- Does your hospital's prescribing guidance include information about when to prescribe oral instead of intravenous medications and intravenous-to-oral switches?
- What educational activities could you plan to encourage discussion within your team about intravenous to oral switches?

How patients were involved in the creation of this article

We spoke to a member of a sustainability group about their experience of receiving intravenous antibiotics. Based on this, we included more detail on the impacts of intravenous-to-oral switch from a patient's perspective.

Contributorship and the guarantor: ME conceived the article and is the guarantor for overall content. SW and CA reviewed, edited, and rewrote the article. A member of a local sustainability group provided a patient's perspective on the topic. All authors approved of the final draft.

Competing interests: SW is an associate of the Centre for Sustainable Healthcare, trustee of the Healthcare Infection Society, and was previously the National Medical Director's clinical fellow at the

National Institute for Health and Care Excellence. CA previously received expenses payment from Biomerieux for work unrelated to this article. ME is currently the chief sustainability officer's clinical fellow and vice chair of sustainability at the Guild of Healthcare Pharmacists.

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