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RESEARCH ARTICLE

Appropriateness of intravenous fluid prescriptions in hospitalised patients: a point prevalence study

Barbara Sneyers[1,2] · Caroline Nyssen[1] · Pierre Bulpa[3] · Isabelle Michaux[3] · Dominique Lacrosse[4] · Philippe E. Dubois[4] · Thomas Rotens[3] · Anne Spinewine[1,2]

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Abstract

Background Inappropriate use of intravenous (IV) fluids results in fluid overload, electrolyte disturbances, and increased costs.

Aim To describe IV fluid prescribing and its appropriateness in hospitalised patients.

Method A point prevalence study was conducted at two sites (academic and general) of a tertiary care hospital in Belgium. All inpatients (except those in the operating theatre) and all IV fluids prescribed during a 24-h period were analysed. Data collected included type, rate and volume administered. Each IV fluid was classified by indication (i.e., resuscitation/replacement, maintenance, catheter patency management, drug administration). Appropriateness was assessed using predefined criteria and validation by attending clinicians.

Results IV fluids were administered to 60% (297) of patients, with a median of 3 [IQR 0.5–6] IV fluid bags per patient and a median daily volume of 1000 ml [IQR 100–1550]. Amongst the 1162 IV fluid prescribed bags, 61.2% (712) were for drug administration, 22.1% (257) for catheter patency, 9.7% (112) for maintenance and 7.1% (82) for replacement/resuscitation. Inappropriate use was found for 56.9% (169) of patients with an IV fluid, representing a median volume of 300 ml per patient [IQR 10–500], and median costs of 4.60 € per patient [IQR 0.4–6.7].

Conclusion Inappropriate IV fluid use is frequent in hospitalised patients, and results in significant costs. Optimisation strategies are needed.

Keywords Fluid Therapy / adverse effects (MeSH) · Fluid Therapy / standards (MeSH) · Infusions · Intravenous (MeSH) · Intravenous fluid · Inappropriate Prescribing (MeSH)

Impact statements

- Monitoring use of IV fluids in hospitalised patients is essential as over half of prescriptions are inappropriate and these lead to significant costs.
- Implementation of IV fluid stewardship strategies must focus on all indications of use, including non-clinical indications (i.e., drug administration and catheter patency), to encompass the majority of IV fluid prescriptions.

Introduction

Intravenous (IV) fluids are commonly given to hospitalised patients [1, 2]. Estimation of IV fluids exposure is complex, however, ubiquitous use is reported, with billions of IV fluid bags used worldwide [3–5]. Belgian data show patients receive on average 7.15 L of IV fluids per stay, with a daily mean volume of 1 L [6]. Internationally, there are few guidelines on IV fluid use [2, 7]. Furthermore, many physicians do not feel confident in their ability to

✉ Barbara Sneyers
Barbara.Sneyers@chuuclnamur.uclouvain.be

1 Department of Pharmacy, CHU-UCL Namur, Av. Gaston Therasse 1, 5530 Yvoir, Belgium

2 Clinical Pharmacy, Louvain Drug Research Institute, Université Catholique de Louvain, 1200 Brussels, Belgium

3 Department of Intensive Care, CHU-UCL Namur, Godinne, Av. Gaston Therasse 1, 5530 Yvoir, Belgium

4 Department of Anesthesiology, CHU-UCL Namur, Av. Gaston Therasse 1, 5530 Yvoir, Belgium

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prescribe IV fluids and electrolytes appropriately [8]. Lack of guidelines and education can lead to inappropriate IV fluid prescribing.

Inappropriate use of IV fluids has harmful consequences. A study in hospitalised patients found rates of 1.3 IV fluid-related errors per patient [9]. Most errors were related to inappropriate dose of IV fluids (administration rates or volume calculation) and inappropriate IV fluid type selection. Most patients are either given too much or too little IV fluids [9–12]. Giving too much IV fluids leads to fluid overload and increased morbi-mortality in critically ill and post-operative patients [12, 13]. Conversly, not giving enough IV fluids results in dehydration and hypernatremia [14–16]. For example, it has been shown that 86% of dehydrated hypernatremic patients did not receive enough electrolyte-free water [14]. Poor IV fluid choice also occurs [9, 17]. Approximately 6–19% of patients are given insufficient electrolytes, leading to hyponatremia and hypokalemia [11, 12]. These imbalances have serious consequences, including death [18, 19]. In fact, a fifth of patients undergoing abdominal surgery experience complications due to inappropriate IV fluid therapy, including arrythmia and pulmonary oedema [12]. In medical patients, 11% of decompensated heart failure patients who received IV fluids in addition to diuretics experienced increased rates of critical care admission and hospital mortality [10]. Therefore, understanding how IV fluids are prescribed is essential in identifying areas for improvement.

There are limited data on appropriateness of IV fluid prescribing in hospitalised patients [17, 20]. With few exceptions [11, 21], data originate from the United Kingdom and the USA [17]. Additionally, studies have focused on surgical or critically ill patients [12, 20–24]. These studies have not analysed the use non-clinical indications for IV fluids (i.e. catheter patency and drug administration), even though these account for up to one third of the IV fluid volumes given to critically ill patients [21]. Finally, IV fluids are one of the top ten categories of drugs with the highest costs for hospitalised patients [1]. Understanding avoidable costs associated with IV fluids can provide valuable pharmacoeconomic information.

Aim

The aim was to describe IV fluid prescribing and its appropriateness in hospitalised patients.

More specifically, objectives were: (1) to describe IV fluid prescribing (indications, types and volumes) across different patient types, (2) to describe appropriateness of IV fluid prescribing, and (3) to describe (avoidable) costs.

Ethics approval

The study was approved by the ethical committee of CHU UCL Namur, Godinne, in 2019 (NUB: BE039201838038). Patient approval was not necessary as no personal patient data were collected.

Method

In 2018, with the goal of improving IV fluid management and practices in our institution (CHU UCL Namur, Belgium), we assembled a multidisciplinary team, with the support of medical and nursing directors. Its responsibilities were to provide guidance, audit and feedback and education on IV fluids management. The team consisted of four intensivists, two anaesthetists, two clinical pharmacists, and a critical care nurse. All members contributed to the present study's conception and design.

A point prevalence study (PPS) was conducted at two sites (academic and general) at our 597-bed tertiary care hospital in Belgium. The study took place over a 24-h period and included all patients hospitalised that day (November 2019), except those in the operating theatre. Use of IV fluids was analysed in all wards, with patients categorised into four types: medical, surgical, emergency department (ED), and intensive care units (ICU).

Our team developed a standardised form, to collect data on patient's units, type of IV fluid and volume prescribed, rate of administration, drugs administered within the IV fluid bag (if applicable), indication and appropriateness. Two pharmacists pre-piloted the form on a five-patient sample, to ensure reliability of data collection. Pilot data were not included in the study. Seven trained pharmacists collected the data. They reviewed prescriptions together with medical notes to identify the indication for each IV fluid. Definitions of indications for the use of IV fluids were provided, based on previous publications (Box 1) [25]. Indications included: resuscitation, replacement, maintenance, managing catheter patency, or IV drug administration. In cases where an IV fluid was used for multiple indications, the most critical indication was prioritised. For example, if an IV fluid was used for both maintenance (clinical indication) and catheter patency (non-clinical indication), it was labeled as used for maintenance.

Next, each IV fluid prescriptions were categorised as appropriate or inappropriate based on criteria defined by our team (Box 2). Only appropriateness of indication was evaluated, appropriateness of type or volume of IV fluid used were beyond the scope of our study. For clinical indications and catheter patency, IV fluid use was considered

Box 1 Definitions of indications for the use of intravenous fluids

Clinical indications

- Resuscitation: fluids used for intravascular hypovolemia correction in patients with hemodynamic compromise
- Replacement: fluids used to maintain fluid balance and/or to correct serum electrolytes, when patients have ongoing losses of fluids and electrolytes (e.g., high urinary output, diarrhea, vomiting, peri-operative losses)
- Maintenance: fluids used to preserve hydric and electrolytic status or to provide calories (ex: glucose), when patients are unable to eat or drink normally for periods exceeding 12 h (e.g., peri-operatively)

Non-clinical indications

- Drug administration: fluids used as vehicles to administer drugs intravenously, through minibag infusions or continuous infusions using syringe drivers
- Catheter patency: fluids used to maintain catheter patency, either as "keep vein open" infusions, either as "flushing" procedures

Box 2 Criteria to determine appropriate and inappropriate use of intravenous fluids per indication

Indication	Appropriate use	Inappropriate use[a]
Clinical indications		
Resuscitation replacement	Patient presents with: -signs and symptoms of hypovolemia (hypotension, tachycardia, oliguria, confusion, cold extremities) -important electrolyte disturbances or fluid losses: gastro-intestinal (diarrhea, nausea-vomiting, fistula, biliary losses…), urinary (polyuria), ongoing blood loss, ascites…	Patient not hemodynamically compromised and no ongoing fluid and/or electrolyte losses
Maintenance	Patient "nil by mouth" or unable to eat or drink (e.g.: confusion, swallowing issues…) for more than 12 h	Patient can eat and drink sufficiently to meet appropriate hydric, electrolytic, and caloric requirements
Non-clinical indications		
Catheter patency	Venous access required for administration of intravenous medications, transfusions, for a planned medical exam, or for patient instability	Venous access no longer required (e.g.: was maintained for an exam which already occurred)
Drug administration	Intravenous fluid used to dilute a drug which may not be administered through an intravenous push technique	Intravenous fluid used to dilute a drug which may be administered through an intravenous push technique (see Supplementary material 1 for detailed list)

[a]Condition was to be met for more than 24-h prior to data collection to meet the criteria for inappropriate use

inappropriate if conditions justifying it's use were absent. For drug administration IV fluid was considered inappropriate if an IV push (IVP) could safely replace the minibag infusion. A pre-defined list of drugs suitable and safe for administration by IVP (detailed list in supplementary material 1) was used. The list was developed by our team, based on manufacturer's recommendations and established sources for IV medication administration [26, 27]. To ensure safety of IVP administration, validation was sought from experienced anaesthetists and infectious disease physicians before inclusion of the drug on the list.

Both, indication and appropriateness ratings assigned by the pharmacists were discussed for confirmation with attending physicians and nurses. IV fluids were considered appropriate if no agreement could be reached.

Total and avoidable costs were calculated for each indication. Costs were considered avoidable when the IV fluid used met the definition for inappropriate use (Box 2). Using official Belgian pricing lists, the IV fluid infusion bags costs were calculated for each prescription. Indirect costs associated with infusion devices, nursing workload or iatrogenic consequences were not considered.

Analysis

Descriptive statistics were performed using R software version 4.1.0 (Computing Software for Statistics, Vienna, Austria). The median and interquartile range [IQR] were computed for continuous variables, and frequencies (n/N) and percentages (%) for categorical variables.

Results

Study population

Data from a total of 495 patients were analysed: 62% (n = 307) were medical patients, 29% (n = 143) were surgical patients, 5% (n = 24) were in the ED, and 4% (n = 21) were in the ICU.

General prescribing patterns

IV fluids were administered to 60% (N = 297) of patients on the PPS day. Among those receiving IV fluids, patients were administered a median of 3 [IQR 0.5–6; range 1–10] IV fluid bags, and a median daily volume of 1000 ml [IQR 100–1550; range 10–4368]. Use, number of IV fluid bags, and volumes administered varied across patient types and care units (Table 1).

Indications for prescribing IV fluids

Indications for IV fluid prescribing varied across patient types (Table 2). In total, 1162 IV fluid bags, were analysed.

Clinical indications

Prescribing IV fluids was scarcely justified by clinical indications, as 9.7% (n = 112) of IV fluid bags were prescribed for maintenance and 7.1% (n = 82) for replacement/resuscitation. A quarter of patients had IV fluids for clinical indications: 16.6% (n = 82) for maintenance and 10.5% (n = 52) for replacement/resuscitation. Median volumes were 1000 ml/day [IQR 100–1500] for maintenance and 1000 ml/day [IQR 100–1550] for replacement/resuscitation.

Non-clinical indications

Non-clinical indications encompassed most IV fluid prescriptions, as 61.2% (n = 712) IV fluid bags were prescribed for drug administration and 22.1% (n = 257) for catheter patency. IV fluids for catheter patency were used in 37.0% of patients, with a median of 1 IV fluid bag per day and a median volume of 500 ml [IQR 10–1000]. Over one third of patients received IV fluids for drug administration (37%, n = 184), with a median of 3 IV fluid bags per day [IQR 1–5] and a median daily volume of 300 ml per patient [IQR 10–420].

Types of IV fluids prescribed

Types of IV fluids used varied according to indications (types and composition of IV fluids in supplementary material 2). Normal saline and Glucose 5% were used in

Table 1 Use of intravenous fluids by patient type and care units

	Proportion of patients with an intravenous fluid % (n/N)[1]	Number of intravenous fluid bags per patient median [IQR]	Daily volume of intravenous fluids administered per patient (ml) Median [IQR]
Medical patients	**55% (169/307)**	**3 [0.5; 5]**	**900 [100; 1400]**
Endocrinology	0% (0/4)	–	–
Gastroenterology	74% (17/23)	4 [1; 5]	1300 [250; 1600]
Oncology	67% (20/30)	3 [1; 5]	610 [100; 1225]
Hematology	100% (27/27)	6 [0.5; 9]	1950 [300; 2925]
Internal medicine	64% (23/36)	4 [1; 6]	1200 [350; 1870]
Cardiology	75% (33/44)	1 [1; 2]	500 [200; 600]
Pneumology	41% (12/29)	2.5 [1; 5]	525 [200; 900]
Neurology	21% (4/19)	1 [0.5; 1.2]	750 [250; 1000]
Geriatrics	51% (25/49)	2 [1; 4]	730 [100; 1000]
Pediatrics	40% (4/10)	5 [3; 6.5]	795 [150; 1412.5]
Physical medicine	13% (2/16)	1.5 [1; 1.8]	850 [100; 1225]
Psychiatry	0% (0/22)	–	–
Maternity	100% (2/2)	4 [2; 5]	1750 [1100; 2075]
Surgical patients	**66% (94/143)**	**3 [1; 6]**	**1085 [100; 2022.5]**
Cardiovascular	68% (17/25)	1 [1; 2]	500 [200; 1000]
Ear Nose Throat	68% (15/22)	3 [1; 5]	1000 [600; 1575]
Neurosurgery	62% (8/13)	4.5 [2; 5.2]	2115 [1100; 2247.5]
Abdominal	81% (30/37)	5.2 [1; 7]	1975 [400; 2490]
Orthopedic	52% (11/21)	3 [1; 5.5]	1000 [500; 1010]
Urological	52% (13/25)	2 [1; 2]	1000 [100; 1100]
Intensive care	**95% (20/21)**	**5 [1; 10.2]**	**970 [100; 1590]**
Emergency department	**58% (14/24)**	**2 [1; 2.8]**	**625 [500; 1000]**

[1]Proportions were calculated amongst the number of patients in each patient type category, among all patients present in the hospital on the PPS day

Table 2 Use of intravenous fluids by indication and patient type

	Proportion of patients with an intravenous fluid[1,2]	Number of intravenous fluid bags per patient	Daily volume of intravenous fluids administered per patient (ml)
Global (N = 495)	**% (n/N)[1]**	**Median [IQR]**	**Median [IQR]**
Replacement and/or ressuscitation	10.5% (52/495)	1 [1; 2]	1000 [100; 1550]
Maintenance	16.6% (82/495)	1 [1; 2]	1000 [100; 1500]
Drug administration	37.2% (184/495)	3 [1; 5]	300 [10; 420]
Catheter patency	37.0% (183/495)	1 [0.5; 2]	500 [10; 1000]
Emergency room (N = 24)	**% (n/N)[1]**	**Median [IQR]**	**Median [IQR]**
Replacement and/or ressuscitation	8.3% (2/24)	1.5 [1; 1.8]	1250 [1000; 1375]
Maintenance	25.0% (6/24)	1 [1; 1]	750 [500; 1000]
Drug administration	29.2% (7/24)	2 [1; 2]	100 [20; 175]
Catheter patency	29.2% (7/24)	1 [1; 1]	500 [10; 500]
Intensive care unit (N = 21)	**% (n/N)[1]**	**Median [IQR]**	**Median [IQR]**
Replacement and/or ressuscitation	33.3% (7/21)	1 [1;1.5]	100 [100;350]
Maintenance	33.3% (7/21)	1 [1;1]	1000 [100;1250]
Drug administration	61.9% (13/21)	5 [1;7]	430 [50;680]
Catheter patency	71.4% (15/21)	2 [1;3.5]	550 [100;900]
Medical patients (N = 307)	**% (n/N)[1]**	**Median [IQR]**	**Median [IQR]**
Replacement and/or ressuscitation	10.1% (31/307)	1 [1;2]	1000 [200;2000]
Maintenance	13.4% (41/307)	1 [1;1]	1000 [250;1500]
Drug administration	33.2% (102/307)	3 [1;5]	300 [40;415]
Catheter patency	32.2% (99/307)	1 [0.5;1]	500 [10;625]
Surgical patients (N = 143)	**% (n/N)[1]**	**Median [IQR]**	**Median [IQR]**
Replacement and/or ressuscitation	8.4% (12/143)	1 [1;1.1]	1000 [500;1000]
Maintenance	19.6% (28/143)	1 [1;2]	1500 [500;1500]
Drug administration	44.1% (63/143)	3 [1; 5]	240 [10; 400]
Catheter patency	44.1% (63/143)	1 [1; 2]	500 [100; 1000]

[1]Proportions are calculated for all patients present in the hospital on the PPS day, amongst the number of patients present globally and within in each patient type category

[2]Prescriptions for different indications may occur simultaneously in individual patients (e.g. a patient may simultaneously receive intravenous fluids for maintenance and drug administration)

most non-clinical indications (69.4% (n = 672) and 26.4% (n = 256), respectively). Noteworthy, 14.4% (n = 37) of IV fluid bags used for catheter patency were more complex solutions (i.e., Glucion® 10%, Plasmalyte® (± Glucose 5%), and NaCl 0.45% + Glucose 5%). Glucose (± crystalloids) or crystalloids alone were used in 68.3% (n = 77) and 31.7% (n = 36) of maintenance prescriptions, respectively. Glucose (± crystalloids) was used in 47.6% (n = 39) of replacement/resuscitation prescriptions, while crystalloids (i.e., Plasmalyte®, NaCl 0.9%) or colloids respectively represented 41.5% (n = 34) and 11.0% (n = 9) of IV fluid bags prescribed for the latter indication.

Inappropriate IV fluid prescriptions

Inappropriate use was documented in 56.9% (n = 169) of patients with IV fluids. Median volume was 300 ml per patient [IQR 10–500]. Inappropriate IV fluids varied by patient type and indication (Table 3). Inappropriate use was found for 43.8% (n = 509) of all IV fluid bags (detailed analysis in supplementary material 3). Inappropriate IV fluids bags represented 26.5% (n = 68) of bags used for catheter patency and 15.5% (n = 27) of bags used for maintenance or replacement/resuscitation. Most bags used for drug administration were classified as inappropriate, as 58.2% (n = 414) of drugs in minibags could have been administered using an IVP. Beta-Lactam antibacterials (penicillins and others), propulsives, drugs for peptic ulcer and gastro-esophageal reflux disease and anti-inflammatory and antirheumatic products (non-steroidal) were the top four drug categories representing 95% of inappropriate IV fluids used for drug administration (Fig. 1).

Table 3 Inappropriate intravenous fluid use by indication and patient type

	Proportion of patients with an inappropriate intravenous fluid[1]	Number of inappropriate intravenous fluid bags per patient[1]	Daily volume of inappropriate intravenous fluids administered per patient (ml)[4]	Costs (€)
Patient type	% (n)[2]	Median [IQR]	Median [IQR]	Median [IQR]
Global (N = 297)	56.9% (169)	1 [1;2]	300 [10; 500]	4.6 [0.4; 6.7]
Emergency room (N = 14)	35.7% (5)	1 [1;3]	210 [50; 250]	2.0 [1.2; 3.7]
Intensive care unit (N = 20)	75.0% (15)	1 [1;2]	180 [50; 390]	5.5 [0.4;8.8]
Medical patients (N = 169)	50.3% (85)	1 [1;2]	300 [10; 480]	3.8 [1.2; 6.6]
Surgical patients (N = 94)	68.1% (64)	1 [1;2]	440 [10; 1025]	4.9 [0.4; 8.4]
Indication (N = 297)	% (n)[3]	Median [IQR]	Median [IQR]	Total[2]
Drug administration	41.8% (124)	3 [1;4]	200 [10; 400]	578.97
Catheter patency	15.8% (47)	1 [1;2]	500 [10; 1000]	169.52
Maintenance	4.0% (12)	1 [1;1.2]	1000 [100; 1125]	96.75
Replacement/ressuscitation	3.4% (10)	1 [1;1]	500 [100;1000]	254.93

[1]Among patients with an intravenous fluid

[2]Proportions were calculated amongst the number of patients in each patient type category

[3]Proportions were calculated among all patients with an intravenous fluid

[4]Total costs on the day of the point prevalence survey

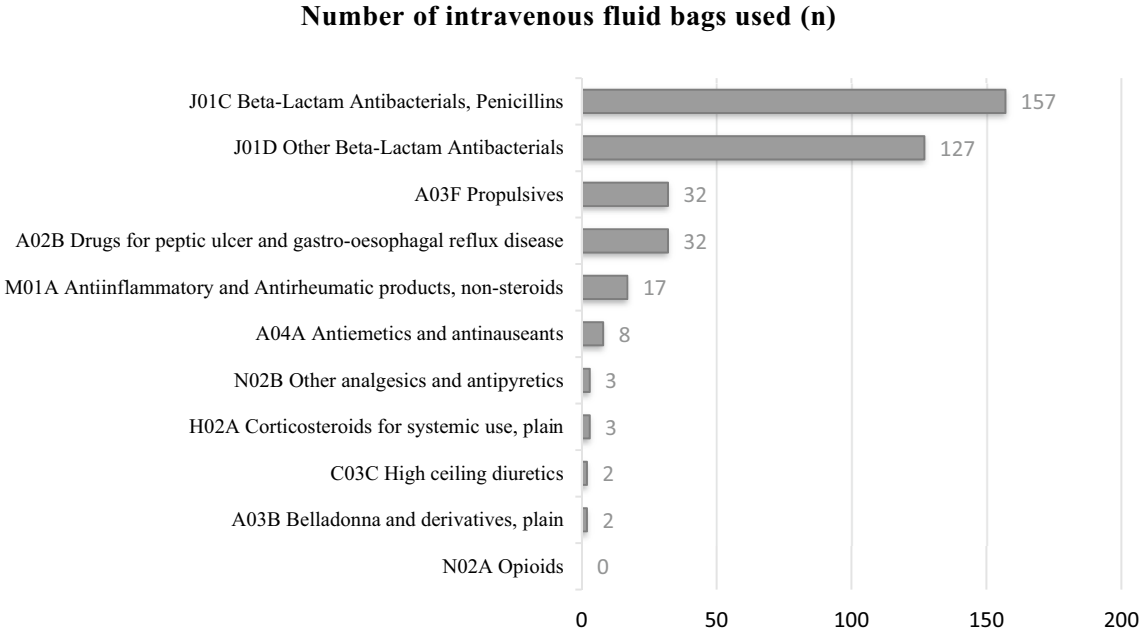

Fig. 1 Drug categories with a potential for intravenous push administration

Costs of IV fluids prescriptions

Total costs of IV fluids represented 3751.22€ on the PPS day. Clinical indications represented 57.8% of costs (37.8% for IV fluids prescribed for maintenance and 20.0% for replacement and/or resuscitation), while 26.9% and 15.3% of costs were attributed to drug administration and catheter patency, respectively. Inappropriate use represented a median daily cost of 4.60 € per patient [IQR 0.4–6.7]. A third (29.3%) of total costs of IV fluid therapy were avoidable.

Discussion

Statement of key findings

In our observational study, IV fluids were administered to most hospitalised patients. Only one in six of IV fluid bags were prescribed for clinical indications. A third of all IV fluid prescriptions were evaluated as inappropriate regarding their indication. Inappropriate IV fluids use was present in more than half of patients.

Opportunities for pharmaceutical care

High rates of inappropriate IV fluid use were found, especially in ICU and surgical patients. This poses a risk of iatrogenic consequences, as fluid overload, which is common in these patients, increases organ dysfunction and mortality [13, 28]. Fluid overload is associated with resource intensive interventions to decrease volume status (i.e. thoracentesis, renal replacement therapies and diuretics) [29]. These costly interventions add to the significant avoidable cost of IV fluids. To address the clinical and economic burden of inappropriate IV fluids, "fluid stewardship" has been advocated [25, 30]. Although engaging multidisciplinary perspectives is essential, clinical pharmacists, as drug specialists, are essential in providing patients with the "four rights" of IV fluids ("right patient", "right drug", "right route", and "right dose") [30]. Research has shown 12–19% of all pharmacists' interventions in medical ICUs were related to IV fluids, representing 1,5–2,4 interventions per patient [31, 32]. Additionally to opportunities in the daily bedside follow-up of prescriptions, potential roles for pharmacists include: (1) ensuring types and volumes of IV fluids available in units are tailored to their specific patient needs; (2) conducting IV fluid use audits and feedbacks; (3) participating in education of healthcare professionals; (4) standardising practices regarding IV fluid use (including non-clinical indications).

Targeting non-clinical indications is crucial

Non-clinical indications represent the largest proportion of IV fluids administered to patients in our study, as in others [21, 33, 34]. These represent the largest modifiable target to reduce fluid overload in ICU patients [33]. Adverse consequences, directly attributed to such IV fluids, include electrolyte disturbances and fluid overload [21, 35–37]. This might counteract the benefit of administering fluids for maintenance and replacement/resuscitation. Prescribing IV fluids for such indications may occur because of system failures, including standardized order sets reflecting hospital or unit habits for drug dilution or catheter patency. Inappropriate requests for IV fluid prescriptions by nurses, may also occur [20]. Therefore, additionally to interventions prompting timely reassessment of IV fluid at the bedside, redesigning IV drug administration and catheter patency policies, as well as engaging nurses is essential.

Targeting IV fluids for catheter patency

A prominent finding in our study was that inappropriate IV fluid use for catheter patency was present for 15.8% of patients, representing a quarter of IV fluid bags which were no longer necessary. Similarly, a study across 51 countries found 14% of patients had inappropriate use of peripheral intravascular catheters, but data is inconsistent, with idle catheters found in 16–50% of patients [38, 39]. Failing to remove catheters in a timely manner poses risks, including phlebitis, occlusion, and catheter-associated bloodstream infections [40]. Bloodstream infections associated with the use of intravascular catheters are considered the most preventable of all healthcare associated infections and are a common cause premature death and disability [40]. To address this, barriers to timely catheter removal need to be dealt with, including improving access to accurate catheter data, defining healthcare professionals' roles in removing catheters, and establishing standardised protocols [41]. Where a catheter is still required, another approach to reduce the burden of IV fluids is to use intermittent flushing for catheter patency instead of continuous infusions [40]. There is no consensus on the preferred approach for keeping IV lines open, but intermittent flushing, using needleless IV connectors, offer benefits like longer catheter patency duration, reduced needlestick injuries, lower costs, and less nursing time [42, 43]. These also increases patient comfort and mobility. However, breaks in aseptic techniques, resulting from low compliance with hub disinfection, lead to contamination and subsequently increase the potential for bloodstream-infections [44]. Therefore, implementing these strategies in hospitals requires careful selection of needleless IV connectors designs and educational interventions.

Targeting IV fluids for drug administration

More than half (58.2%) of IV fluid bags used for drug administration could have been avoided by using an IVP administration technique instead of IV minibag infusions. It has been argued that IVP administration is a "risky business", as injecting doses faster than recommended is the most common type of error during IV drug administration [45]. The Institute for Safe Medication Practices (ISMP) has received numerous reports of IV push errors involving patient injury, prompting the development of guidelines to improve safety of such practices [46]. Concerns for adverse effects specifically related to the IVP technique include a

high risk for infusion reactions and phlebitis with highly concentrated medication. Despite these concerns, some hospitals have used IVP strategies widely, without documenting safety issues [47, 48]. Studies focusing on specific drugs (including PPIs, antiepileptics, antibiotics), especially in the context of emergency situations, showed safety of IV push and similar rates of adverse effect compared with IV minibag infusions [49–54]. Additionally, substantial benefits are associated with using IVP administration. First, time to drug administration is reduced by 30–60 minutes, which is especially important in emergency situations [53–55]. Second, we hypothesise patient surveillance may be improved, as the nurse is present at the bedside during the whole process of drug administration. Third, costs are reduced with studies showing savings of 4–8 $US per dose (primarily due to elimination of minibags and IV tubings and reduced administration time) [56]. In our study, we found using an IVP strategy could result in substantial savings. Fourth, such strategies may potentially improve hospitals' carbon footprint as IV bags and tubings constitute 20–25% of hospital's plastic waste [57]. Despite these advantages, several barriers, including perceived increased nursing workload and patient risk, negatively impacting engagement of nurses to use IVP techniques. Implementing IVP administration widely includes careful drug selection for an IVP policy and incentives such as prefilled syringes, although these are not widely available [58].

Strengths and weaknesses

Our study has both strengths and limitations. Firstly, we focused on prescribing patterns, which may only represent a small portion of the overall harm caused by IV fluids. Another study has found that most of voluntarily reported IV fluid incidents occur during the dispensing/preparing and administration phases [59]. However, we collected prospective observational data, effectively identifying prescribing issues. Secondly, we relied partially on documentation to determine the indications and appropriateness of IV fluid bags, which is known to be poor in this area [60]. Nevertheless, our methodology involved evaluations conducted by trained clinical pharmacists, using clear definitions for indications and appropriateness. These evaluations were confirmed by attending physicians and nurses. Therefore, we likely captured the physicians' intended indications, unlike previous observational studies that relied solely on dose and administration rates to determine indications [21]. Thirdly, specific subtypes of patients, such as those in the ED and ICU, represented a small proportion of patients included in the study. This limits our ability to draw definitive conclusions about these populations. However, all patients in these units on the day of the PPS were included, and 14% of all IV bags on that day were used in such patients.

Further research

Further research is needed to improve patient outcomes. Firstly, a prospective longitudinal approach may provide a better understanding of patient harm. Secondly, qualitative research is necessary to explore causes of inappropriate prescribing and prescribers' perspectives. Lastly, research focusing on strategies tailored to each indication of IV fluids, particularly those minimizing use for catheter patency and drug administration, is crucial to influence patient outcomes and costs of care.

Conclusion

We found that IV fluids were administered to most hospitalised patients, yet only a minority of bags were prescribed for clinical indications. Inappropriate use of IV fluids was identified in more than half of patients, highlighting the need for improvement in practices. Implementing strategies tailored to each indication of IV fluids is likely to minimise iatrogenic complications and costs.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11096-024-01816-9.

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