



Risks of Intravenous Fluid Therapy by First Year Residents – A Prospective Study

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Authors' contributions

This work was carried out in collaboration between all authors and included the study design and writing the protocol. Author AL collected the initial dataset. Author JS wrote the first draft of the manuscript which was finalized by all authors working collaboratively. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Intravenous fluid prescriptions are common in hospitals and most are written by junior doctors. Despite the frequency in which clinicians prescribe IV fluids, the burden from mortality and morbidity related to IV fluids is huge with an estimate that 1 in 5 patients are harmed by inappropriately prescribed fluids. We wished to identify the deficiencies in foundation year 1 doctors' (FY1s, first year of clinical practice after graduation) knowledge and practice of IV fluid prescribing and to identify barriers to good prescribing practice that they had encountered on the wards. FY1s are in their first year of internship after graduating from medical school and this UK experience may be mirrored across the world.

Study Design: A prospective, mixed methods study was carried out, using questionnaires, educational interventions and post-interventional evaluation.

Place and Duration of Study: Royal Liverpool & Broadgreen University Hospitals NHS Trust, Prescott Street, Liverpool, UK. The study took place over 2015.

Methodology: A 53 point questionnaire was designed and used to sample data. An educational intervention was designed after a gap analysis and post-intervention sampling to assess the efficacy

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of the interventions was also carried out.

Results: Significant deficiencies were revealed in the ability to prescribe maintenance fluids. 33% of doctors (n = 8) had not read any guidance about IV fluid prescribing. 42% (n = 10) of participants adhered to fluid prescribing guidance. 17% (n=4) doctors stated that they did not know the contents of fluid bags they prescribed. Only 25% (n = 6) of first year residents indicated that they adhered to weight based prescribing and 4% and 16% felt they at times prescribed too much sodium or water, or too little potassium, for maintenance. Most residents (92%, n=22) reported checking patient's latest urea and electrolyte values prior to prescribing IV fluids and 54% (n=13) indicated that they reviewed the patient clinically prior to prescribing fluids. However, 67% (n = 16) reported not documenting IV fluid therapy and fluid status in the case notes. The analysis of the narrative data showed system barriers, such as nurses not weighing patient weight, as contributing to the deficiencies in prescribing correctly. The intervention was successful in reversing the deficiencies to a large extent. However cultural and system barriers were also identified.

Conclusion: Cultural and system barriers are significant in any learning and need to be taken into account when designing healthcare improvements.

Keywords: Medical education; intravenous fluids; foundation year doctors.

1. INTRODUCTION

Intravenous fluids (IV fluids) are one of the most commonly prescribed medications in hospitals [1]. Despite the frequency in which clinicians prescribe IV fluids, the burden from mortality and morbidity related to IV fluids is huge with an estimate that 1 in 5 patients are harmed by inappropriately prescribed fluids [1]. Common causes of harm include fluid overload, electrolyte imbalances and dehydration [2-4]. The prescribing of intravenous (IV) fluids is an important aspect of patient safety in the day to day running of a hospital [1,5]. Various compositions and regimes of fluids are used regularly in clinical practice with common indications including the resuscitation of acutely unwell patients, post-operative care and to provide maintenance fluid requirements in those who have a reduced or restricted oral intake. Realising the risk to patients, the National Institute for Health and Care Excellence in the UK (NICE) produced guidelines on the use of IV fluids in 2013 [1].

The main prescribers of IV fluid have been shown to often be the most junior members of the medical team [6,7] and a large proportion of this work occurs on-call for patients who are unfamiliar to the prescribers [5]. Given that the majority of IV fluid prescribing falls to the junior members of the team, it is disheartening that many newly qualified doctors feel they lack the necessary competence or confidence in prescribing IV fluids [8,9].

Given the impact that accurate fluid prescribing has on patient safety we aimed to identify the

deficiencies in foundation year 1 doctors' (FY1s, first year of clinical practice after graduation, first year residents) knowledge and practice of IV fluid prescribing and to identify barriers to good prescribing practice that they had encountered on the wards. FY1s are in their first year of internship after graduating from medical school. For the purpose of this study we chose to focus on the prescribing of maintenance fluids. We chose this study to enable us to make informed changes to the FY1 induction and teaching curriculum, improve our undergraduate prescribing curriculum, and, depending on any barriers identified, to provide a starting point for further changes.

2. METHODS

A 53-point questionnaire (Appendix 1) was designed to capture data points including awareness and use of existing guidance, amount of training received in fluid prescribing and level of knowledge of the principles of fluid prescribing. These were scored on a five-point Likert scale. In addition there were 2 practical assessments in fluid prescribing (maintenance fluid prescriptions for a 40 kg and 70 kg man), and 6 narrative data capture sections. The questionnaire was designed around the key priorities for implementation highlighted in the NICE fluid guidance 1 as well as questions to ascertain participant's attitudes towards IV fluid prescribing. Participants were asked to indicate their perceived knowledge of IV fluid prescribing including the composition of various types of IV fluids and an individual's daily water and electrolyte requirements.

Initial data was collected from a consecutive sample of FY1 doctors in November 2014 and analysed in an Excel spreadsheet. Narrative data were analysed by 'constant comparative' [10] method to identify key themes.

During the year FY1s received 5 lectures on IV fluids as part of their weekly teaching schedule. A repeat focused 12-point survey using selected quantitative questions on weight based prescribing and good practice in fluid prescribing from the initial questionnaire, as well as qualitative and quantitative feedback on the teaching they had received that year (Appendix 2) was re-distributed to the same FY1 doctors after 6 months.

3. RESULTS

3.1 Initial Results

In total 24 questionnaires were completed. Of the 60 FY1s in the trust, 28 were administered the survey, giving a response rate of 40% (all FY1s) or 85% (FY1s at survey). Participants were from a range of different universities – of those sampled, 39.3% (n=11) were from the University of Liverpool with the remainder from a wide range of universities across England and Wales.

All but one participant reported prescribing IV fluids every day, with the majority (58%) indicating that they prescribe IV fluids for an average of 5 or more patients each day (Fig. 1).

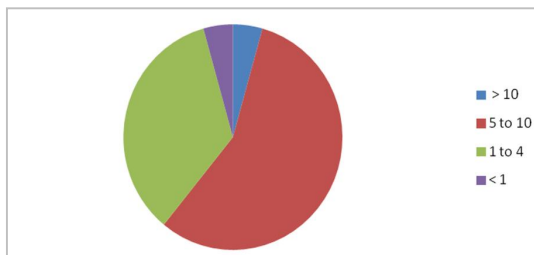


Fig. 1. How many patients do you prescribe fluids for each day (on average)?

The themes identified by analysis of the narrative were: awareness and attitudes of IV fluid prescribing guidance; knowledge of IV fluid prescribing concepts; attitudes towards IV fluid prescribing; barriers to good IV fluid prescribing and good practice in IV fluid prescribing.

3.1.1 Awareness and attitudes of IV fluid prescribing guidance

63% (n = 15) of participants reported an awareness of or NICE guidance (either strongly agreed or agreed), and 33% of doctors (n = 8) admitted to not having read any guidance about IV fluid prescribing. Only 42% (n = 10) of participants indicated that they adhered to fluid prescribing guidance. Of those who had read the guidance, five people reported finding NICE guidance complicated and eight who felt that the trust IV fluid prescribing policy was complicated. Overall the majority of doctors felt that they would know where to locate both the NICE and trust guidance (50% and 75% respectively).

3.1.2 Knowledge of IV fluid prescribing concepts

All participants reported having a good knowledge of the different uses of IV fluids (e.g. replacement/maintenance). 58% (n = 14) of participants felt that they knew the electrolyte composition of fluid bags regularly prescribed with a further 21% (n = 5) choosing a neutral response. 17% (n=4) doctors stated that they did not know the contents of fluid bags they prescribed. The questionnaire then asked participants to complete the electrolyte composition of a one litre bag of 0.9% Sodium Chloride and Hartmann's solution (Table 2). 25% (n = 6) of FY1s indicated that they adhered to weight based prescribing and 4% and 16% (n = 1 and 4) felt they at times prescribed too much sodium or water, or too little potassium, for maintenance.

46% and 67% of participants correctly identified two scenarios where excess fluids had been prescribed (e.g. identifying as a case of fluid over-prescription the statement 'I prescribe routine maintenance as 3L of fluids'). Participants were then asked to complete an example 24 hours maintenance IV fluid regime for a patient weighing 40 kg and then again for a patient weighing 70 kg. Ideal maintenance fluid requirements are outlined in Table 2.

It should be noted that only 18 participants completed the example fluid prescriptions. Variations indicated in Table 3 were allowed to take account of medications (fluid bag volumes and potassium supplements) available in trust.

Analysing the example prescriptions for a 40 kg patient, all participants prescribed too much

water with only 12.5% (n = 3) prescribing 1.5 litres. The rest included prescriptions with at least 2 litres of water. 4% (n=1) of participants prescribed an appropriate amount of sodium and 12.5% (n=3) participants prescribed the correct amount of potassium. 4% (n=1) prescribed a completely appropriate fluid regime.

Regarding the 70kg patient, the majority of participant's example regime contained excess water: 16.7% (n=4) of participants prescribed 2.5 litres of water and 83.3% (n=20) prescribed 3 litres of water. 8.3% (n=2) of prescriptions contained an adequate amount of sodium and 25% (n=6) added an appropriate amount of potassium to the fluids given. 4% (n=1) prescribed a completely appropriate fluid regime. 8.3% (n=2) of participants prescribed three litres of fluids for both patients.

3.1.3 Good practice in IV fluid prescribing

92% (n=22) of participants reported checking patient's latest urea and electrolyte values prior to prescribing IV fluids. 54% (n=13) indicated that they reviewed the patient clinically prior to prescribing fluids and 67% (n = 16) reported not documenting IV fluid therapy and fluid status in the case notes.

3.1.4 Attitudes towards IV fluid prescribing

Participants were asked to rate the importance they placed on both medication and IV fluid prescribing on a ten point scale (1 = not important, 10 = very important).

Fig. 2 shows the distribution of responses.

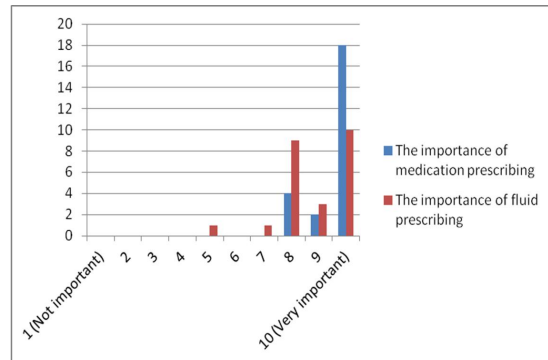


Fig. 2. Distribution of responses

In a separate question 83% (n = 20) said they were aware of the risks associated with the prescription of IV fluids.

3.1.5 Fluid prescribing in hospital: Barriers to good IV fluid prescribing

Participants felt that there were several barriers to the prescription IV fluids. 88% (n = 21) felt that there was poor documentation of a patient's weight on prescription charts. Opinion was however mixed as to whether fluid balance was adequately measured and documented in the patients notes (21% felt that it was done well, 17% were neutral and 54% felt it was poorly documented). 83% (n = 20) felt pressured from nursing staff to prescribe fluids quickly.

Table 1. Participant responses to fluid composition exercise

	Specialty	Correct (n)	Total correct	Incorrect (n)	Total Incorrect	Not answered (n)	Total not answered
0.9% NaCl	Medical	1	5 (21%)	5	9 (38%)	6	10 (41%)
	Surgical	4		4			
Hartmanns solution	Medical	2	3 (13%)	4	11 (46%)	6	10 (41%)
	Surgical	1		7			

Table 2. Ideal fluid requirement as per NICE (2013) guidance

	Amount required for a 40 kg patient/per 24 hours (permitted variation)	Amount required for a 70 kg patient/per 24 hours (permitted variation)
Water	1.2 litres (1.5litres)	2.1 litres (2-2.5 litres)
Sodium	40 mmol	70 mmol
Potassium	40 mmol	70 mmol (60 – 80mmol)
Chloride	40 mmol	70 mmol

With regards to out of hours fluid prescribing, 50% (n = 12) of participants felt too busy to prescribe IV fluid whilst on call, and 58% (n = 14) identified that the vast amount of IV fluid prescriptions were for patients they were unfamiliar with. 17% (n=4) of participants reported prescribing a 24 hour regime of fluids for patients to avoid the need for out of hours prescribing.

Participants reported a lack of supervision and senior doctor overview when prescribing IV fluids. 38% (n = 9) felt they prescribed IV fluids unsupervised and unsupported compared to 21% (n = 5) who reported feeling supported. 17% (n = 4) answered that their senior doctors checked fluid prescriptions during ward rounds.

3.1.6 Suggestions for improving IV fluid prescribing practices

Several suggestions were made by participants as to how IV fluid prescribing could be changed to promote better practice and ease of prescribing. Only 10 (41%) of doctors felt that the current prescription chart design included everything that was needed. Suggestions for improving it included adding space for notes, electrolytes results and parameters for when patients should receive IV fluids. Participants also suggested methods to improve awareness of guidelines e.g. flow charts in clinical areas and pocket sized reminder cards. Participants also felt that their education of IV fluid prescribing would benefit from the inclusion of practical workshops and ward based teaching.

Repeat questionnaire (after 6 months)

20 FY1s responded and the key themes identified in the initial questionnaire were

reassessed including weight based prescribing, practical assessment, clinical and biochemical review of patients prior to prescribing, and out-of-hours prescribing prevention. Participants were also asked for feedback on the fluid prescribing teaching sessions they had received.

3.1.6.1 Weight based prescribing and clinical or biochemical review of patients prior to prescribing

80% (n=16) of participants reported that they followed weight based prescribing in comparison to 25% (n=6) on the initial questionnaire. Of note is that in line with NICE guidance for fluid maintenance, 35% (n=7) used the fluid 'dextrose saline' in their prescriptions. This is in comparison to no respondents using this fluid choice in the initial questionnaire. 100% (n=20) of FY1s reported checking electrolytes and 75% (N=15) reviewed the patient clinically before prior to prescribing fluids.

3.1.6.2 Out-of-hour prescribing and other barriers to good prescribing practice

On reassessment 61% (n=11) agreed that they prescribed 24 hour fluid regimes when appropriate to prevent out-of-hour prescribing. 22% (n=4) were neutral, and 16.8% (n=3) disagreed. This is an improvement from 16.8% (n=3) who indicated they prescribed 24 hour regimes when appropriate initially.

Barriers identified by participants as preventing good prescribing practice were similar to the initial questionnaire. They included poor documentation of patient weight and fluid balance, poor nurse education about fluid prescriptions, poor senior support, and conflicting advice on fluid from different seniors.

Table 3. Comparison of correct prescriptions for a 40 kg and 70 kg patient in November and July

Scenario	November 2014 questionnaire		July 2015 questionnaire	
	% of correct prescriptions for volume of water (n)	% of correct prescriptions for amount of potassium (n)	% of correct prescriptions for volume of water (n)	% of correct prescriptions for amount of potassium (n)
Maintenance fluid prescription in a 40 kg patient	12.5% (3)	12.5% (3)	50% (10)	60% (12)
Maintenance fluid prescription in a 70 kg patient	16.7% (4)	25% (6)	35% (7)	50% (10)

Table 4. Participant perceptions on teaching

Statement	% Good or very good (n)	% Poor or very poor (n)	% Neutral (n)
Rating of teaching on IV prescribing a the Royal Statement	75% (15)	10% (2)	15% (3)
Do you feel your practice has changed as a result of the teaching you've received?	% Definitely or probably has 75% (15)	% Probably or definitely not 20% (4)	% Neutral 5% (1)

3.1.6.3 Perceived impact of teaching

Participant responses to questions about teaching provided on fluid prescribing can be seen in table 4. Narrative responses to the question about how teaching could be improved suggested small group practical sessions instead of didactic lectures, and teaching earlier in the year.

4. DISCUSSION

In December 2013 NICE produced UK national guidelines on the use of IV fluids [1]. In them, they set out best standards for not only the prescription of IV fluids, but also the management of patients receiving them including continued assessment and monitoring of electrolytes. Despite this guidance there is evidence that the prescription of IV fluids continues to be highly variable and is still a cause of iatrogenic harm [11]. As Gnanasampanthan and colleagues [7] state, “the production of guidelines does not guarantee their implementation”. In our small study we have indeed shown this to be true - despite the NICE and trust guidance on fluid prescribing being freely available online, there are still significant deficits in FY1s knowledge of the composition of commonly prescribed fluids and appropriate weight based maintenance fluid regimes.

First year medical residents, or FY1s [known as Foundation Year 1] doctors carry out much of the prescribing on the clinical ‘shop floor’. Hence we wished to examine their abilities.

Particularly worrying was the finding that two months after starting their FY1 post, only 25% of our study population reported prescribing by weight. While this did improve to 80% at the end of the year, prescribing by weight is a core principle of accurate fluid prescription and should be taught well as an undergraduate. This finding is in keeping with the existing literature. A study by Powell et al. [9] evaluating FY1 doctors

knowledge of IV fluids indicated that 49% of their study population had a below average knowledge (scored 2 out of 5 on assessment, with 5 being the highest score), and a separate study [7] also reported that over 50% of IV fluid prescriptions on a surgical ward were incorrect.

What is concerning from a patient safety perspective is that many participants seemed to lack awareness of their own knowledge deficits. Most participants felt confident they knew the electrolyte composition of commonly used IV fluid bags, yet only 36% of those who agreed or strongly agreed with the statement ‘I know the contents of the bags of fluids I prescribe’ could accurately describe the contents of at least one bag of IV fluid. The lack of awareness of their own absence of knowledge can be described as a failure of metacognition. Metacognition is the awareness of one's own knowledge, and the ability to reflect on, monitor, direct and evaluate learning [12,13]. As the body of medical knowledge continues to grow and evolve, metacognition is increasingly recognised as an important skill for doctors to develop to enable them to identify their own learning needs [12-14]. Participants in this study still displayed failures in metacognition in the July assessment, with 80% of participants stating they prescribe by weight yet only 35-50% being able to prescribe the correct volumes. These findings call into question the level of metacognitive skills our recent graduates possess, and whether the teaching and support methods we are using in postgraduate teaching are helping to develop these metcognitive abilities.

So why, despite the introduction of clear IV fluid prescribing guidelines, are FY1s still performing poorly? While the FY1s in our study displayed poor levels of metacognition surrounding IV fluids they all confirmed that they were taught it at undergraduate level. Thought must therefore be given to the way IV fluid prescribing is taught, and whether the teaching methodologies utilised

at undergraduate level are promoting retention and transferability into the ward based setting. Given that our assessment took place after the FY1s had been working in the trust for several months our results suggest that the teaching students are receiving at the undergraduate and early postgraduate level is not equipping them with this knowledge [3,11,15].

Our study highlights additional barriers to good prescribing; in particular the burden of out of hour prescribing to unfamiliar patients, poor senior support, and a lack of adequate nursing documentation regarding patients weight or fluid balance. The latter observation potentially offers a contributing factor to why fluids are rarely prescribed according to weight, despite this being an integral aspect of accurate fluid prescription. These observations emphasise the need for a multidisciplinary approach to good prescribing such as improved nursing training on principles of fluid therapy (recommended in the NICE 2013 guidelines) and the necessity of medical and surgical teams to support their juniors and work to provide 24 hour fluid plans for their patients.

5. FUTURE STUDY DIRECTIONS

Our study identified a range of factors affecting junior doctor's ability to adhere to good prescribing practice. These include a lack of awareness of guidelines, poor metacognitive skills, inadequate fluid-balance documentation, a reliance on out of hour fluid prescribing and a lack of senior supervision. Given these deficits it is clear that junior doctors working in hospital require additional or improved training regarding IV fluid therapy. The format to best provide this support and generate a demonstrable change in behaviour, as well as improving theoretical knowledge, is less clear. Interventions such as lectures, work-shops, posters on wards and pocket sized fluid protocols have shown to be beneficial in previous studies [7,15-17]. Especially useful has been the training of both junior and senior clinicians to improve consultant support and a multidisciplinary approach involving medical, surgical, nursing and pharmacy teams [17]. Taking into account the need to develop metacognitive skills as well as improve knowledge, the literature would suggest that interactive teaching sessions (as suggested by participants) encouraging reflection, goal-setting and feedback would serve to improve performance on both counts [13]. Given our findings the study team is currently developing

improved teaching programmes for our fourth year students in collaboration with the pharmacy team and assisting in developing the junior doctor induction and early teaching programme. More work needs to be done regarding which teaching methods are most effective in improving the long-term knowledge and practice of high quality fluid prescribing, and how to support educators to modify their teaching methods accordingly.

6. LIMITATIONS

There are a number of factors which we acknowledge will limit the applicability and generalisability of these questionnaire results. Firstly, the number of FY1 doctors involved was relatively small - only 24 (initially) and 20 (later) out of 60 FY1s in the trust at the time completed the survey. The questionnaire also only focussed on assessing participant's knowledge of prescribing maintenance fluids. Whilst this is important, a large amount of IV fluid therapy is given for other reasons (e.g. fluid replacement/resuscitation). It is also worth noting that participant's knowledge was tested out of the clinical environment. This may have had an impact upon how accurately they answered the questions, particularly those regarding display of knowledge.

7. CONCLUSION

Prescribing IV fluid therapy is an important, yet often complex, process with varying practices throughout the medical profession. It is for this reason that best practice guidance exists, however it is clear that this is not being adhered to in our. Work needs to take place in order to improve junior doctors' knowledge and competence at prescribing IV fluids, and also to change culture at a system level to ensure best practice is encouraged and promoted. The factors identified in our study are likely to be present in other centres and in a range of subject areas, prompting the question of whether metacognitive skills need to be developed in the undergraduate and postgraduate curricula.

CONSENT

It is not applicable.

ETHICAL APPROVAL

Institutional approval was gained for this work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Appendix 1 – Questionnaire

The following questions relate to F1 perspectives of fluid prescribing. The aims are to evaluate the most significant causes of variation and inadequate fluid prescribing and therefore highlight areas for improvement.

How often do you prescribe fluids?	> 10 patients a day	5 – 10 patients a day	1 – 5 patients a day	< 1 patients a day	Never
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What specialty do you currently work in?

I am aware of fluid prescribing guidance (choice and weight based)	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I have read the fluid prescribing guidance	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I understand the fluid prescribing guidance	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I adhere to fluid prescribing guidance	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I know the risks, benefits and harms of IV fluids	Strongly agree	Agree	Neutral	Disagree	Strongly disagree

Please rate out of 10 your knowledge of fluid prescribing – 1 = Poor, 10 = Excellent	1	2	3	4	5	6	7	8	9	10
Please rate out of 10 your adherence to guidelines for fluid prescribing – 1 = Poor, 10 = Excellent	1	2	3	4	5	6	7	8	9	10
Please rate out of 10 the importance of medication prescribing – 1 = Not important, 10 = Important	1	2	3	4	5	6	7	8	9	10
Please rate out of 10 the importance of fluid prescribing – 1 = Not important, 10 = Important	1	2	3	4	5	6	7	8	9	10

Fluid Prescribing Policy and Guidance

I know where to find trust policy	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I know where to find NICE guidance	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The trust policy is complicated	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The NICE guidance is complicated	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I know the difference between maintenance, replacement and resuscitation prescribing	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I know individuals water, electrolyte and glucose requirements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I know the contents of the bags of fluids I prescribe	Strongly agree	Agree	Neutral	Disagree	Strongly disagree

I would improve the ease to use guidance in fluid prescribing by....

Fluid Prescribing Education

I was prepared in order to begin prescribing fluids	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I was taught fluid prescribing with lectures/tutorials as an undergraduate	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I was taught fluid prescribing with practical teaching (ward based/practical prescribing) as an undergraduate	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I was taught fluid prescribing as a postgraduate (including E Learning)	Strongly agree	Agree	Neutral	Disagree	Strongly disagree

I would improve fluid prescribing education by...

How were you taught fluid prescribing (and by who)

Fluid Prescribing Adherence

I follow weight based fluid prescriptions (Maintenance - Water 25-30 ml/Kg, 1 mmol/kg Na, Cl and K)	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I prescribe too much water for maintenance	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I prescribe too much sodium for maintenance	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I prescribe too little potassium for maintenance	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I prescribe Hartmann's as routine maintenance (Over 24 hours – 3L Hartmann's 8 hourly)	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I prescribe routine maintenance (for a 70kg patient) as 3L fluids (2L 5% dextrose, 1L 0.9% Saline)	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I clinically review patients and read notes prior to prescribing fluids	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I document fluid status and indication in case notes	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I check up to date urea and electrolytes prior to prescribing fluids	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Fluid balance is adequately measured and documented	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The weight of a patient is documented on fluid prescription charts	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I prescribe fluids for all patients for the next 24 hours to avoid out of hours prescribing	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I handover patients that require further fluid balance review and prescriptions of fluids to the on call doctor	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I review fluid requirements/status for patients that have been transferred to my ward on call	Strongly agree	Agree	Neutral	Disagree	Strongly disagree

Any suggested interventions or improvements to ensure fluid prescribing adherence to guidance?

Fluid Prescription Chart

Fluid prescription chart design meets the current needs for fluid prescribing	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Fluid prescriptions require identification regarding prescriber (e.g. Bleep Number, Print Name)	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Fluid prescription charts would benefit from a column for indication for IV fluids	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I check EPMA prior to prescribing fluids (e.g. Sando K)	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I think fluid prescribing should be electronic	Strongly agree	Agree	Neutral	Disagree	Strongly disagree

I would improve the current fluid prescription chart by....

General

My seniors check my fluid prescriptions and fluid charts on ward rounds	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I feel supervised and supported when fluid prescribing	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The large quantity of my fluid prescribing is whilst on call for patients I do not know	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I feel too busy/high workload on day job to prescribe fluids	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I feel too busy/high workload on call to prescribe fluids	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I feel pressured by nursing staff to prescribe fluids quickly	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I forget to prescribe fluids	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I report consequences of fluid mismanagement as a critical incident	Strongly agree	Agree	Neutral	Disagree	Strongly disagree

What in your opinion are the main causes and possible barriers of inappropriate fluid prescriptions?

Please rate out of 10 your ability to assess fluid status and prescribe fluids in the following situations.

	Poor										Excellent									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
High Gastrointestinal losses (Stoma, NG, Diarrhoea)	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Diabetic Ketoacidosis or Hyperosmolar coma	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Sepsis including the elderly	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Pre-existing cardiac disease	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
New renal disease	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Chronic kidney disease	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10

Please prescribe maintenance fluids for a 40 kg patient with normal urea and electrolytes.

No significant past medical history.

Infusion volume	Infusion solution	Name and dose of additive	Duration of infusion

Please prescribe maintenance fluids for a 70 kg patient with normal urea and electrolytes.

No significant past medical history.

Infusion volume	Infusion solution	Name and dose of additive	Duration of infusion

Please fill in (or estimate) the electrolytes (in mmol) for each 1L bag.

Electrolytes	0.9% Saline	Hartmann's solution
Sodium		
Chloride		
Potassium		

Appendix 2 – Repeat Questionnaire

IV fluid questionnaire

I follow weight based fluid prescriptions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I know the composition of the fluids I prescribe	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I clinically review patients and read notes prior to prescribing fluids	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I check up to date urea and electrolytes prior to prescribing fluids	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I prescribe fluids for all patients for the next 24 hours to avoid out of hours prescribing	Strongly agree	Agree	Neutral	Disagree	Strongly disagree

Please prescribe maintenance fluids for a 40 kg patient with normal urea and electrolytes.

No significant past medical history.

Infusion volume	Infusion solution	Name and dose of additive	Duration of infusion

Please prescribe maintenance fluids for a 70kg patient with normal urea and electrolytes.

No significant past medical history.

Infusion volume	Infusion solution	Name and dose of additive	Duration of infusion

How would you rate the teaching you have received on IV fluid therapy at the Royal Liverpool	Very good	Good	Neutral	Poor	Very poor
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Do you feel your practice has changed as a result of teaching in FY1 protected time?	Definitely changed	Probably changed	Neutral	Probably not	Definitely not
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Do you have any suggestions about how fluid prescribing teaching could be improved?

Do you have any suggestions about how barriers to good fluid prescribing on the wards could be improved?

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