Evaluation of the implementation of the alert issued by the UK National Patient Safety Agency on the storage and handling of potassium chloride concentrate solution

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Objectives: To assess the effectiveness of the response of NHS hospital trusts to an alert issued by the National Patient Safety Agency designed to limit the availability of concentrated potassium chloride in hospitals in England and Wales, and to determine the nature of any unintended consequences.

Design: Multi-method study involving interviews and a physical inspection of clinical areas.


Participants: Senior managers and ward based medical and nursing staff.

Main outcome measures: Degree of staff awareness of and compliance with the requirements of the national alert, withdrawal of concentrated potassium chloride solutions from non-critical areas, provision of pre-diluted alternatives, storage and recording in accordance with controlled drug legislation.

Results: All trusts required that potassium chloride concentrate be stored in a separate locked cupboard from common injectable diluents (100% compliance). Unauthorised stocks of potassium chloride were found in five clinical areas not authorised by the trust (98% compliance). All trusts required documentation control of potassium chloride concentrate in clinical areas, but errors were recorded in 20 of the 207 clinical areas visited (90% compliance). Of those interviewed, 78% of nurses and 30% of junior doctors were aware of the alert.

Conclusions: The NPSA alert was effective and resulted in rapid development and implementation of local policies to reduce the availability of concentrated potassium chloride solutions. The success is likely to be partly due to the nature of the proposed changes and it cannot be assumed that future alerts will be equally effective. Continued vigilance will be necessary to help sustain the changes.

It has been estimated that adverse events feature in around 10% of admissions to hospital, affecting 850 000 people a year,1 costing the NHS in the region of £2 billion,2 and causing pain and suffering to patients. It was in order to reduce the incidence of such incidents that the National Patient Safety Agency (NPSA) was established in 2001 to monitor adverse incidents and improve patient safety in England and Wales. This body, like its counterparts in the US and in Australia, made concentrated potassium products the subject of its first alert.3–5

The fatal consequences of inappropriate administration of strong potassium chloride solution have been acknowledged for many years. The substance has been used inadvertently instead of sodium chloride to flush IV lines; instead of water for injection to reconstitute antibiotics; or has been confused with frusemide, a loop diuretic with which it is frequently given.6 7 Such confusion is exacerbated by the fact that high concentration potassium chloride is produced by a variety of manufacturers in ampoules that commonly resemble those containing sodium chloride and water for injection (fig 1). Even when diluted, the substance may give rise to problems because its hyperbaric properties make adequate mixing difficult. However, because blood potassium levels below 2.5 mmol are potentially fatal and need urgent and carefully titrated correction, many clinicians have opposed previous attempts to remove it from clinical areas. A summary of the alert is given in box 1 and full details are available from the NPSA website (http://81.144.177.110/site/media/documents/486_riskalertpsa01.pdf).

Given that this was the first directive from a new NHS organisation, it was important to study its effect so, 1 month after the publication of the alert by the NPSA, we were commissioned to evaluate its impact. The study aims were to examine the receipt, dissemination, and management of the alert and to assess the extent of compliance with its requirements. Data collection started 1 week after the date
found that most pharmacy departments held their own list of “authorised areas”. In each trust at least five authorised and five unauthorised wards were visited and audited for availability, storage, and recording of potassium chloride using an audit checklist (see Appendix 3 available online at http://www.qshc.com/supplemental). Researchers inspected all drug cupboards, drug trolleys, other storage facilities, and preparation surfaces in both patient areas and in clinical preparation rooms. In addition, they examined opened boxes and containers holding sterile water and sodium chloride for injection and examined books used for recording the use of potassium. In total, 207 areas were inspected.

**Ward staff interviews**

A convenience sample of eight registered nurse ward managers and two junior doctors in each trust was interviewed to ascertain their awareness of the NPSA requirements and to explore any problems that had arisen since the implementation of the alert (see box 2 for definitions of staff types). In total, 166 ward managers (or their nominees) and 37 junior medical staff were interviewed in addition to 14 others including night nursing staff. A structured interview schedule was used for these interviews and these were coded and analysed using SPSS.

**Audit trail**

Trusts were asked to provide evidence of action taken in advance of and immediately following the alert. These data—consisting of policies, memos and minutes of meetings—were used to triangulate the information given in the interviews.

**RESULTS**

The results reported here represent a distillation of data from all sources. The themes emerging from the senior manager interviews and the open questions in the structured interviews with ward staff related to previous action, dissemination, awareness and reaction, implementation of the guidance (storage, recording and authorisation), actual and potential unintended consequences and unresolved issues.

**Previous action taken**

Interviews with senior managers revealed that 19 trusts (95%) had previously taken some prior action to reduce dependence on the concentrated solution although only one was fully compliant with all aspects of the guidance at the

**Interviews with senior managers**

All medical directors, clinical governance leads, chief pharmacists, chief nurses and clinical risk managers were approached for interview using a semi-structured format. We also interviewed others identified as having a key role in the dissemination and implementation process. Specific data were recorded on the interview schedules with these 70 senior managers to enable the development of descriptive statistics, but interviews were also recorded and transcribed.

Data analysis was concurrent and clear thematic categories and subcategories emerged. These categories were developed by two researchers working independently, and differences compared and reconciled by discussion. Differences between trusts and groups of respondents were examined using analytical matrices.

**Ward audits**

Although the NPSA alert named some specific clinical areas that would require continued access to the concentrate, it also referred to “other specialist critical care areas” and it was found that most pharmacy departments held their own list of

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**Box 1 Requirements of the NPSA alert on potassium products**

Potassium chloride (KCl) concentrate solutions and other strong potassium solutions should be:

- restricted to intensive care environments;
- prepared in pharmacies when no commercial product of the correct concentration is available;
- subject to the same recording processes as controlled drugs;
- stored in a locked cupboard;
- signed for by a second practitioner;
- not transferred between clinical areas.

**Box 2 Definitions of professional roles**

- Medical director: trust board member representing doctors
- Clinical governance lead: executive member of trust board with responsibility for clinical quality
- Ward manager/ward sister/charge nurse: registered nurse in charge of ward
- Junior doctor: all non-consultant grades
- Clinical risk manager: person responsible for undertaking risk assessments and identifying and addressing actual and potential clinical risk
- House officer: newly qualified doctor in pre-registration year
- Senior house officer: registered doctor who has completed a minimum of 1 year’s practice after qualifying.
time the alert was published. All managerial claims were substantiated by the audit trail.

Dissemination, awareness, and reaction
Interviews with ward based personnel revealed that an average of 135 nurses (79%) and 11 doctors (30%) were aware of the alert and could provide information concerning the provisions. Most nurses welcomed the action taken, typical comments being:

"It's not about making our jobs more difficult, it's about protecting us. It's been quite reassuring and improved safety. It recognises that we are humans and we do make mistakes." (Ward sister)

"The guidance has resulted in the benefit of having peace of mind." (Staff nurse)

There was considerable variation in the means by which nursing and medical staff at ward level had become aware of the policy or its provisions (table 1). Circulation of the policy, staff meetings, and oral communication by pharmacists appeared to be the most effective mechanisms for communicating with nursing staff, whilst memos, emails, and overheard conversations were the means by which most junior doctors had received the information. The ward interviews revealed that doctors were, almost without exception, unaware of any procedures relating to storage and recording of drugs or of obtaining them out of hours, claiming that these were nursing responsibilities.

Authorisation of areas
Four pharmacists reported having discussions with the NPSA to determine whether they could authorise theatres or paediatric units to hold the concentrated solution and had been told that this was possible, subject to a full risk assessment. The range in the number of areas authorised to hold the concentrate was 2–11 for small trusts; 4–11 for medium trusts, and 5–27 for large trusts.

Eighty seven of the 207 areas visited were found to be in possession of concentrated potassium chloride solution (table 2). Eighty two of these were named in trust policies as authorised. Of the five areas in three trusts that were not authorised, two (accident and emergency and renal unit) lay within the NPSA’s definition of critical care areas and two were theatre recovery areas, which had been authorised in other trusts. Strong potassium chloride solution was found on only one general medical ward (from which it was promptly removed by the lead pharmacist) and no potassium phosphate was found outside intensive care units.

Storage
The audit revealed that, of the 87 wards and departments in which strong potassium chloride was found, in 70 cases it was stored in the controlled drug cupboard, in seven in the outer drug cupboard, and in 10 in a separate locked cupboard (100% compliance). Storage of potassium dihydrogen phosphate was also in line with the alert. Overall, it was clear that in the majority of areas the storage space for controlled drugs was inadequate for its purpose and, had potassium chloride been made a true controlled drug under the provisions of the act, many trusts would have required a wholesale replacement of these cupboards. As it is, in most wards these tiny cupboards are piled high with drugs, frequently necessitating the removal of several boxes to locate the drug required.

Recording
Fifty seven (65%) of the areas in which the strong solution was found were recording its use in a controlled drug register and 25 (29%) were using a separate potassium register. Five (6%) were not making any record. The failure to record the use of strong potassium chloride was an error in four cases

| Table 1 Percentage of each staff group reached by stated means of communication |
|---------------------------------|-----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|
| Staff group                     | Guidance/policy | Memo            | Email           | Routine meeting | Orally by        | Other           | Educational     |
|                                 | circulated      |                 |                 | meeting         | pharmacist       |                 | event           |
| Ward sister/Charge nurse        | 27.0%           | 25.2%           | 15.3%           | 12.6%           | 27.9%           | 27.9%           | 3.6%            |
| Staff nurse                     | 18.2%           | 47.3%           | 3.6%            | 14.5%           | 12.7%           | 21.8%           | 0.0%            |
| House officer                   | 5.6%            | 61.1%           | 0.0%            | 5.6%            | 5.6%            | 50.0%           | 5.6%            |
| SHO                            | 0.0%            | 7.1%            | 0.0%            | 0.0%            | 14.3%           | 50.0%           | 0.0%            |
| Specialist registrar            | 20.0%           | 0.0%            | 20.0%           | 20.0%           | 20.0%           | 40.0%           | 0.0%            |
| Other                          | 50.0%           | 28.6%           | 28.6%           | 21.4%           | 21.4%           | 21.4%           | 0.0%            |

Figures do not sum to 100% as some respondents quoted more than one source of information.

| Table 2 Wards audited indicating whether or not authorised to stock strong potassium chloride solution |
|---------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Wards and departments                       | No of authorised | No of unauthorised | Total visited | KCI found in  |
|                                            | areas visited   | areas visited   |               | unauthorised area | Recording error found in at least one entry in book |
| Accident & emergency                        | 5               | 5               | 10             | 1               | 4               |
| Coronary care                                | 12              | 4               | 16             | 1               | 1               |
| High dependency                              | 6               | 4               | 10             | 1               | 2               |
| Intensive care                               | 28              | 1               | 29             | 1               | 1               |
| Medical                                      | 2               | 53              | 55             | 1               | 1               |
| Obstetrics                                    | 3               | 2               | 5              | 3               |
| Paediatric                                   | 5               | 1               | 6              | 1               |
| Renal unit                                    | 2               | 2               | 4              | 2               |
| Surgical                                     | 0               | 35              | 35             | 2               |
| Special care baby unit                       | 10              | 0               | 10             | 2               |
| Theatre – recovery                           | 7               | 6               | 13             | 2               |
| Theatre – anaesthetics                       | 2               | 2               | 4              | 1               |
| Other                                        | 0               | 5               | 5              |
| Total                                        | 82              | 125             | 207            | 5               | 20              |
and a deliberate strategy in one intensive care area where the
staff maintained that they already recorded and double
signed the administration of potassium chloride in the
patient’s care plan and so refused to sign the controlled drug
register for the preparation, citing pressure of time.

“The hardest bit of the guidance has been the double checking and
signing for … given that they already had to double sign the treatment
card and double sign the label and what they were very
concerned about was taking a one to one nurse away from a patient to
go to a cupboard.” (Clinical risk manager)

In addition to these five wards, auditors noted 13 cases in which second signatures were missing and two in which
patients’ names were not recorded.

Out of hours arrangements
No pharmacy in any of the 20 trusts visited was open for
24 hours. Typically, out of hours arrangements, as described
by senior managers and confirmed by policy documents,
indicated that the first action was to borrow a stronger
commercially prepared solution from another ward area or,
through the nurse in charge, to access these from an
emergency drug cupboard. If these measures proved insufficient,
the on-call pharmacist was to be contacted. In one trust
the nurse in charge had authority to dispense with the on-call
pharmacist in specific life threatening clinical emergencies,
providing certain conditions were met.

Actual and potential unintended consequences
Senior managers were asked whether they had concerns
about any unintended consequences of the implementation
of the guidance. Five stated that there was a need to monitor
whether restrictions were impeding access to potassium for
patients who required it. This was of particular concern in
cardiac theatres and cardiac intensive care units where
potassium levels can fall quickly.

“In cardiac surgery you do actually use large volumes of potassium
and some of it is actually not prescripted by doctors but perfusionists –
the people who drive the cardiopulmonary bypass. Their role includes
putting potassium into the heart lung machine. In a way, cardiopulmonary perfusionists are practitioners in their own right
and they have their own system of registration.” (Consultant
anaesthetist)

Concern was also expressed at the potential for deskilling
staff in non-authorised areas, bearing in mind that all but
four trusts retained the right to make the strong solution
available for named patients on unauthorised areas. Some
managers pointed out the need for constant vigilance lest the
concentrate find its way back into unauthorised areas as a
result of lack of storage space for, or non-availability of,
commercially produced solutions or for reasons of cost or
access. Finally, two were anxious about inappropriate use of
the stronger solutions (40 mmol in 100 ml; 50 mmol in 50
ml) of which clinicians had no prior experience.

“There was a fear that we were changing the risk from the
ampoules to the 40 mmol in the 100 ml bags. Firstly, they are
unlicensed and, secondly, although not as concentrated as the
injection, they can still cause harm so we had to demonstrate that we
weren’t merely transferring the risk from one preparation to
another.” (Chief pharmacist)

One pharmacist reported a recent case of a consultant
giving the stronger solution as a bolus injection through a
peripheral vein.

Unresolved issues
Both managers and ward staff were invited to comment on
any issues arising from the alert and some of their responses
have been embedded in sections above.

There had been a few recorded instances of problems
encountered since the implementation of the guidance. Staff
on paediatric and other wards with specific patient groups
cardiacy surgery) were concerned about having to go through
complex processes in the middle of the night to obtain the
concentrate, although these were not common complaints.

“Fluid-restricted patients present a major challenge. The rigmarole
to get hold of the concentrate in the middle of the night is ridiculous.”
(Ward sister)

There were also issues for manufacturers. Eighteen
managers and ward staff stressed the need to address the
packaging and labelling of ampoules and of IV solutions
containing potassium to clearly differentiate them and so avoid confusion (fig 1).

“After all that has been said about this, it is obscene that the
ampoules are so similar to water and sodium chloride. You would
have thought that they would have done something about it by now.”
(Registered nurse)

“The red writing on the IV bags is on the side of the bag. You need
it on the front of bag in red.” (Registered nurse)

Others stated that the sudden rise in demand for 40 mmol
potassium chloride in 100 ml solutions of sodium chloride or
glucose was creating problems for manufacturers and
stressed the importance of these substances being constantly
available.

“We had to wait three months for the glucose bags – there is no
point in doing all this unless we can ensure a constant supply,
otherwise people will go back.” (Assistant chief pharmacist)

DISCUSSION
There are a number of limitations to this study. The 20 NHS
trusts that agreed to take part may not be an unbiased sample
even though the given reasons for non-participation were
unrelated to the research study reported here. Trusts had
avoided 6 weeks warning of our audit which may have
prompted implementation of the alert, although in all cases
the audit trail revealed activity from the date of the alert or
earlier, rather than commencing after our first contact.
Finally, the audit was carried out immediately after the
implementation date and thus we may have failed to identify
problems that had yet to surface, and conversely identified
easily resolvable problems. The main strengths of the study
lie in the physical inspection and audit trail which verified
both the accuracy of interview data and the effectiveness of
the management action.

Overall, the dissemination process from the NPSA to the
trusts and thence to senior managers had worked well. The
alert was welcomed by all pharmacists interviewed who felt
that it had lent authority to their efforts to restrict the
availability of concentrated ampoules and to promote the use
of commercially available dilutions. This illustrates a poten-
tial value of these communications in providing strong
central backing for the views of a significant professional
group which may stimulate more action from senior
managers than would otherwise be the case.

The list of areas permitted to stock potassium ampoules left
trusts some room for manoeuvre and, on advice from the
NPSA, most trusts had carried out a risk assessment and had
added general theatres, labour wards, and paediatric wards to
their list of authorised areas. There was wide variation in the
number of wards authorised within trusts of the same size,
which may indicate further room for removal of the
concentrate from clinical areas.

The only opposition to the requirements of the alert came
from intensive care staff, and particularly from those
involved with cardiac surgery patients, who cited as a
problem the time consuming nature of the new procedures
caused by the location of some controlled drug cupboards
and the fact that the drugs could only be checked out
ampoule by ampoule to address the immediate need of the
patient.

www.qshc.com
The potentially fatal consequences of the inappropriate administration of concentrated potassium chloride have been acknowledged for many years. 

In 2002 the newly formed National Patient Safety Agency (NPSA) made the substance the subject of its first alert.

All 20 trusts visited had taken action in response to the alert (100% compliance).

The substance was found in five clinical areas which were not authorised by the trusts to stock it, although only one of these was a general ward (98% compliance).

78% of nurses and 30% of junior doctors were aware of the alert and could describe at least some of its requirements.

Recording errors were found in 20 of the 207 areas visited (90% compliance).

Senior staff welcomed the intervention of the NPSA in assisting the implementation of a policy widely held to be in the interests of patient safety.

Given that the literature is peppered with tales of patient deaths arising from the confusion of potassium chloride with sodium chloride and water for injection, it seems inappropriate that the packaging and labelling has not been made more distinctive.

Poor awareness on the part of junior doctors, despite the commendable efforts of some pharmacists to communicate, was a source of concern. The numbers interviewed in this study are too small to justify recommendations in relation to this finding, nor did any of the senior manager respondents have any suggestions as to how to cope with this constantly changing resource. However, there may be strength in the prevailing view of the junior doctors that the management of drugs was purely the province of nursing staff. Nurses may both figuratively and literally ‘hold the key’ to this problem and, if they are provided with prescribing guidance in relation to the administration of the potassium, they can challenge prescriptions that they perceive to be inappropriate.

Our research suggests that strong potassium chloride has been successfully removed from nearly all inappropriate clinical areas and there is reason for optimism that this may result in a marked reduction in sentinel events, as was reported in the US. The finding is compatible with those reported in the US. The finding is compatible with those reported in the US. The safety alert was compatible with the shared norms and values of health professionals and was relatively simple to implement, in that no new skills were required, nor significant resources entailed. New directives such as that aimed at reducing the risk of wrong site surgery which are more complex and which also challenge professional styles, may prove more difficult to implement. For most staff there are likely to be fewer response barriers. However, the indifference of junior doctors suggests that sustaining the policy implementation may be challenging with some groups. Continuing vigilance of pharmacy departments, with annual random monitoring checks, may be required to ensure that ampoules do not effect a gradual return to unauthorised wards by prescription on a named patient basis. Cost, lack of storage space, inconsistent availability of some of the newer stronger solutions, and the difficulties in accessing concentrated potassium chloride out of hours may also contribute to its return.

CONCLUSION

The NPSA alert was effective, resulting in a rapid implantation of local policies to reduce the availability of concentrated potassium chloride solutions. The success is likely to be partly due to the nature of the proposed changes and future alerts may not be equally effective. Continued vigilance will be necessary to help sustain the changes.

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REFERENCES

6 Cousins DH, Upton DR. Medication error: lethal ampoules are still being issued. Pharmacy in Practice 1995;5:130–2.
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