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1 Title Page

2
3 **Acute kidney injury electronic alerts: mixed methods Normalization**
4 **Process Theory evaluation of their implementation into secondary**
5 **care in England**
6

7 Jason Scott,^{1*} Tracy Finch,¹ Mark Bevan,¹ Gregory Maniatopoulos,² Chris
8 Gibbins,³ Bryan Yates,⁴ Narayanan Kilimangalam,⁵ Neil S Sheerin,^{3,6} Nigel Suren
9 Kanagasundaram,^{3,6*}

10
11 ¹ Faculty of Health and Life Sciences, Northumbria University, Newcastle upon Tyne, England

12 ² Institute of Health and Society, Newcastle University, Newcastle upon Tyne, England

13 ³ Renal Services, Newcastle upon Tyne Hospitals NHS Foundation Trust, Newcastle upon Tyne,
14 England

15 ⁴ Northumbria Healthcare NHS Foundation Trust, Newcastle upon Tyne, England

16 ⁵ Gateshead Health NHS Foundation Trust, Gateshead, England

17 ⁶ Institute of Cellular Medicine, Newcastle University, Newcastle upon Tyne, England
18

19 ***Corresponding author**

20 Dr Jason Scott

21 Faculty of Health & Life Sciences

22 Northumbria University

23 Coach Lane Campus West

24 Newcastle upon Tyne

25 England

26 NE7 7XA

27 jason.scott@northumbria.ac.uk

28
29 **Word count: 3,920**

30 **ABSTRACT**

31 **Objective**

32 Around one in five emergency hospital admissions are affected by acute kidney injury (AKI). To address
33 poor quality of care in relation to AKI, electronic alerts (e-alerts) are mandated across primary and
34 secondary care in England and Wales. Evidence of the benefit of AKI e-alerts remains conflicting, with
35 at least some uncertainty explained by poor or unclear implementation. The objective of this study
36 was to identify factors relating to implementation, using Normalization Process Theory (NPT), which
37 promote or inhibit use of AKI e-alerts in secondary care.

38

39 **Design**

40 Mixed methods combining qualitative (observations, semi-structured interviews) and quantitative
41 (survey) methods.

42

43 **Setting and participants**

44 Three secondary care hospitals in North East England, representing two distinct AKI e-alerting systems.
45 Observations (>44 hours) were conducted in Emergency Assessment Units (EAUs). Semi-structured
46 interviews were conducted with clinicians (n=29) from EAUs, Vascular or General Surgery, or Care of
47 the Elderly. Qualitative data were supplemented by NoMAD surveys (n=101).

48

49 **Analysis**

50 Qualitative data were analysed using the NPT framework, with quantitative data analysed
51 descriptively and using Chi Square and Wilcoxon Signed Ranks Test for differences in current and
52 future normalization.

53

54 **Results**

55 Participants reported familiarity with the AKI e-alerts but that the e-alerts would become more
56 normalized in the future ($p<0.001$). No single NPT mechanism led to current (un)successful
57 implementation of the e-alerts, but analysis of the underlying sub-constructs identified several
58 mechanisms indicative of successful normalization (*internalization, legitimation*) or unsuccessful
59 normalization (*initiation, differentiation, skill set workability, systematization*).

60

61 **Conclusions**

62 Clinicians recognised the value and importance of AKI e-alerts in their practice, though this was not
63 sufficient for the e-alerts to be routinely engaged with by clinicians. To further normalize the use of
64 AKI e-alerts, there is a need for tailored training on use of the e-alerts and routine feedback to
65 clinicians on the impact that e-alerts have on patient outcomes.

66

67 **Key words**

68 Acute kidney injury, Normalization Process Theory, Implementation, Mixed methods, Human factors,
69 Patient safety

70

71 **ARTICLE SUMMARY**

72 **Strengths and limitations**

- 73 • This is the first known mixed methods study to use Normalization Process Theory to
74 investigate the implementation of AKI e-alerts, providing a unique lens on their
75 implementation
- 76 • The study was conducted in clinical areas where AKI incidence is high; it is unknown whether
77 the e-alert would be more useful (and whether it would be more or less poorly implemented)
78 in clinical areas where AKI incidence is lower.
- 79 • The study was also conducted in one region, and so implementation of the AKI e-alert may
80 have been influenced by local networks.
- 81 • It is unknown whether the e-alerts had a quantifiable impact on AKI outcomes or staff actions,
82 and so it is not possible to draw conclusions about the effectiveness of the AKI e-alerts studied
83 as a result of implementation.

84
85 **INTRODUCTION**

86 Acute kidney injury (AKI) affects around one in five emergency hospital admissions.¹ AKI is both
87 dangerous, with around 15,000 excess deaths in National Health Service (NHS) England inpatients per
88 year,² and costly, imposing an estimated additional financial burden on this system of £1.02 billion per
89 annum.² Increasing age and co-morbidity in the hospital population has increased the number of
90 patients at risk from the condition, which is only likely to rise further with an ageing population. AKI
91 care itself is often poor, with systematic failings in its recognition and management, and frequent
92 omissions of even the basics of care.³

93
94 AKI alerting systems are mandated for all NHS England primary and secondary care providers, using a
95 biochemical detection algorithm⁴ and usually implemented electronically. The algorithm, which
96 appears to perform with a high degree of sensitivity (>90%),⁵ has resolved ambiguities in modern
97 diagnostic criteria⁶ around how to interpret baseline serum creatinine (SCr), a historical impediment
98 to the standardisation of automated AKI detection, and as well as outputs for the three stages of
99 disease severity, it also flags out-of-range SCrs in the absence of an historical baseline. AKI electronic
100 alerts (e-alerts) are thought to improve patient outcomes by improving early detection of AKI and
101 triggering earlier intervention by clinicians.⁷ The exact nature of the AKI alerts is not, however,
102 dictated, and may take a number of forms.

103
104 The efficacy of AKI e-alerts is limited and has not shown consistent benefit⁸ in terms of reduced
105 mortality or use of renal support, or positive impacts on processes of care,⁹ which may be the result
106 of alert fatigue^{5,10} or disrupted workflow.¹⁰ Inadequate implementation can explain the poor
107 outcomes, particularly as there are some examples of improved care processes¹¹ and treatment
108 outcomes through successful implementation.¹²⁻¹⁴ Mandatory incorporation of AKI alerts into all
109 secondary care organisations in England lacked a clear implementation strategy, and recently
110 published systematic reviews recognised large variation in implementation,¹² with an association
111 between poor implementation and poor outcome.⁹ One review specifically identified a paucity of
112 research on the implementation of AKI e-alerts internationally.⁹ To address this paucity of research,
113 the present study aimed to identify factors relating to implementation which promoted or inhibited
114 use of AKI e-alerting systems in secondary care.

115

116 **METHODS**

117 This study incorporated mixed methods (qualitative interviews and observations combined with
 118 quantitative surveys) to investigate the implementation of AKI e-alerts from multiple perspectives,
 119 including observations, surveys and semi-structured interviews. Normalization Process Theory
 120 (NPT)^{15,16} was chosen as the theoretical basis for the study as it is an internationally recognised theory
 121 of implementation that has been used to explain successful and suboptimal implementation in over
 122 100 healthcare initiatives,¹⁷ including through the use of mixed methods.¹⁸⁻²⁰ NPT therefore provides
 123 the explanatory power for understanding how complex interventions, such as AKI e-alerts, become
 124 integrated into existing practice through individual and collective implementation. This integration is
 125 proposed to occur via four mechanisms: ‘Coherence’: how people make sense of what needs to be
 126 done, ‘Cognitive participation’: how relationships with others influence outcomes, ‘Collective action’:
 127 how people work together to make practices work, and ‘Reflexive monitoring’: how people assess the
 128 impact of the new intervention. The four constructs are operationalised under 16 sub-constructs,
 129 which are described in table 1.

130

131 **Table 1:** Description of NPT mechanisms and sub-constructs

<p>Coherence Differentiation: How participants understand a set of practices and their objects to be different (or not) from each other. Communal specification: Extent to which participants have a shared understanding of the aims, objectives, and expected benefits of a set of practices. Individual specification: How participants understand their own specific tasks and responsibilities around a set of practices. Internalization: How participants perceive the value, benefits and importance of a set of practices.</p>	<p>Cognitive Participation Initiation: Whether or not key participants are working to drive a new set of practices forward. Enrolment: The extent to which participants organize or reorganize themselves and others in order to collectively contribute to the work involved in new practices. Legitimation: The work of ensuring that other participants believe it is right for them to be involved in the new set of practices, and that they can make a valid contribution to it. Activation: The work that participants do collectively to define the actions and procedures needed to sustain a new practice and to stay involved.</p>
<p>Collective Action Interactional Workability: The interactional work that people do with each other, with tools/systems, and with other elements of a set of practices, when implementing a new practice. Relational Integration: The work that is needed to build accountability and maintain confidence in a set of practices and in each other as they use them. Skill set Workability: The allocation of work amongst participants with different roles and skills in relation to the new set of practices. Contextual Integration: The work of managing a set of practices through the allocation of different kinds of resources and the execution of protocols, policies and procedures to support the practices.</p>	<p>Reflexive Monitoring Systematization: The work undertaken by participants to determine how effective and useful the new set of practices is for them and for others, and the information collected to enable this. Communal appraisal: The work undertaken by participants collectively (sometimes in formal collaboratives, sometimes in informal groups) to evaluate the worth of a set of practices. Individual appraisal: Individual participants’ own appraisals, based on their experiences, of the effects of a new set of practices on them and the contexts in which they are set. Reconfiguration: The extent to which appraisal work by individuals or groups may lead to respecification or modification of the set of practices.</p>

132

133 **Sampling and recruitment**

134 Three NHS Trusts in North East England were invited to take part in the study based on being within a
 135 single NHS Trust's renal department catchment area, and the catchment area for referral for complex
 136 AKI (see table 2 for a description of Trusts and their AKI e-alerting systems). Three clinical areas were
 137 purposively chosen for study at each NHS Trust based on anticipated high levels of AKI incidence; (1)
 138 Emergency Admissions, (2) Internal Medicine/Care of the Elderly, and (3) General/Vascular Surgery.
 139

140 **Table 2:** Characteristics of participating NHS Trusts and their AKI electronic e-alert. See Additional
 141 files 1 and 2 for images of the e-alerting systems.

NHS Trust	Trust Characteristics	AKI electronic alert
Trust 1	University-affiliated, 1800 bed, multiple site tertiary referral hospital; contains regional renal unit, transplantation, cardiothoracic and hepato-biliary surgery as well as other major specialisms; The Renal Unit is based at one Trust site and although providing consultative input to the rest of the Trust, has no routine, on-site presence at these venues which include the emergency admissions suite and significant sections of general surgical, internal medical and elderly care services.	<p>Passive electronic alert consisting of a line of black text appearing underneath serum creatinine results in the patient's electronic medical record (<i>Powerchart, Cerner Millennium, Cerner Corporation, Kansas, MO, USA</i>) which stated the stage of AKI where present.</p> <p>Additional pop-up electronic alert that appeared when accessing the patient's electronic medical record, and required dismissal to remove from the screen. A 'more info' link on the pop-up window, if clicked, took the end-user to a second window that contained further links to the Trust AKI protocol and specific guidance on aspects of management including essential assessments, key bedside observations & key investigations. The latter linked to quick order test panels including essential blood tests and urgent renal ultrasound requesting.</p>
Trust 2	Multi-site university-affiliated district general with approximately 900 beds. All acute services on one site with internal medicine, elderly services, general and orthopaedic surgery along with obstetrics and paediatrics. Renal replacement provision from critical care. Renal input, provided from Trust 1 by remote consultation, no renal consultant presence within the trust.	<p>Passive electronic alert consisting of a line of black text appearing underneath serum creatinine results in the patient's electronic medical record (<i>TelePath Information Management System, Mill Systems Limited, Belper, UK</i>) which stated the stage of AKI where present.</p> <p>Alert does not link with any other hospital information system, but instructs users to access local AKI guidelines.</p>
Trust 3	District general hospital with 300 beds in medicine. Renal input is from Trust 1 through a combination of remote consultation and weekly availability at the time of an out-patient clinic on site.	<p>Passive electronic alert consisting of a line of black text appearing underneath serum creatinine results in the patient's electronic medical record (<i>Medical Information Technology (MEDITECH) Inc., Westwood, MA, USA</i>) which stated the stage of AKI where present.</p> <p>Alert does not link with any other hospital information system, but instructs users to access local AKI guidelines.</p>

142
 143 Participants for semi-structured interviews were purposively sampled based on specialty and clinical
 144 experience (determined by grade). Participants were invited through direct contact by JS, or by leaving
 145 contact details after completing a survey. Recruitment to survey was conducted through direct contact

146 by JS, or electronically via an internal email by (or on behalf of) the lead consultant for the clinical
147 specialty. Teaching sessions at Trust 3 were also used to invite staff to participate in the survey. Access
148 to observe practice on emergency admission units was facilitated by the lead consultant(s) for the
149 unit. Participants were able to take part in the research activities (interviews, observations and/or
150 survey) in any order, based upon what was most convenient. Where possible, the order of activities
151 was balanced to reduce confounding variables.

152

153 **Data collection**

154 Semi-structured interviews were conducted by a male research associate, JS (PhD), with participants
155 in their place of work or via telephone between May 2017 to September 2017, and lasted an average
156 of 26 minutes (range 17 to 41). Interviews were recorded using a digital voice recorder and transcribed
157 verbatim by a professional transcription company. A topic guide (see Additional file 3) was constructed
158 by the research team based on the four mechanisms of NPT (coherence, cognitive participation,
159 collective action, reflexive monitoring; see table 1) and from previous qualitative work on
160 implementation of AKI e-alerts.¹⁰ In addition to questions based on the four NPT mechanisms, the
161 topic guide also included questions about the participants' clinical experience (job role, length of time
162 in role, experience in other roles) and their experience with AKI e-alerts. Ethnographic data were
163 obtained by JS by observing practice in emergency admission units, guided tours, shadowing of staff,
164 and informal conversations and handover meeting attendance. Observational data were documented
165 in fieldnotes.

166

167 The Emergency Admission Units function to provide early assessment of adult patients referred via
168 their general practitioner or the emergency department. One of the units (Trust 3) was a hybrid
169 Emergency Admission Unit and Acute Medicine ward. A total of 44.25 hours of observations were
170 conducted at various times of day (morning, afternoon and evening) during the working week
171 (Monday to Friday).

172

173 The NoMAD survey,²¹⁻²³ a validated instrument for measuring implementation,²⁴ was adapted for use
174 with AKI e-alerts (see Additional file 4). Questions were added to identify characteristics of
175 respondents, including:

176

177

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179

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183

184 In addition, five questions from the Hospital Survey on Patient Safety Culture™ (SOPS™; version 1.0)²⁵
185 were included. SOPS™ contains a construct containing four questions titled 'Overall perceptions of
186 patient safety'. All four questions from this construct were included, along with an overall patient
187 safety grade. Paper and electronic versions of the study survey were made available to potential
188 participants. All data collection was conducted after the AKI e-alerts had been implemented into
189 practice for at least one year.

190

191 **Data analysis**

192 Framework analysis was used for qualitative data,²⁶ with the four NPT mechanisms and their sub-
193 constructs forming the framework (see table 1). For interview data, one interview transcript was
194 jointly charted by JS and TF, with interpretations of the data discussed until agreement was reached.
195 This discussion familiarised JS with the differential meanings underpinning the 16 sub-constructs for
196 subsequent analysis of qualitative data, as TF is an expert in NPT as a co-developer of the theory.^{22,23}
197 JS then charted the remaining interview data into the framework. For observational data, in-depth
198 observer notes were summarised by the observer (JS), then all observation data were charted into the
199 framework jointly with TF.^{15,16} NVivo software (*QSR International Pty Ltd, version 10*) was used to
200 facilitate coding of qualitative data. Once initial analysis was complete, all authors reviewed and
201 discussed the coding in a team meeting before coming to agreement on the final interpretations,
202 which is an established process of qualitative data analysis.²⁷ Participants were not invited to comment
203 on findings.

204

205 IBM SPSS Statistics for Windows (*IBM Corp, version 24.0*) was used for quantitative analysis. Inferential
206 statistics (chi square) were used to compare patient safety culture between NHS Trusts and specialties
207 to identify whether safety culture could influence the subsequent analysis. Wilcoxon Signed Ranks
208 Test was used to analyse differences in current and future normalization of the e-alerts. Survey items
209 relating to the four NPT mechanisms were then analysed by examining descriptive statistics for each
210 of the four mechanisms. Mechanism scores for each participant were created by taking their average
211 score in each mechanism and dividing by the number of valid responses, which stopped data from
212 being skewed where respondents stated a question was not applicable. Higher scores represent better
213 perceived implementation in relation to each mechanism. Data were then triangulated by exploring
214 (dis)agreements and silences across the qualitative and survey data sets. This was conducted by a
215 single researcher (JS) identifying and listing sub-constructs that demonstrated particularly high or low
216 normalization, comparing these against qualitative themes and then discussed amongst the research
217 team.

218

219 **Patient and public involvement**

220 There was no patient and public involvement in the design or planning of the study.

221

222 **RESULTS**

223 Semi-structured interviews were conducted with 29 staff members. 28 interviews were with doctors,
224 and one interview was with a pharmacist involved in implementing AKI e-alerts at Trust 1. The survey
225 was distributed to 157 staff, and 102 (65%) responded. 94 (92.2%) completed the paper version, and
226 eight (7.8%), the online version. See table 3 for a summary of interview participants and survey
227 respondent characteristics. Table 3 also acts as a key to participants' grades, which is used to infer
228 level of experience (grades are competency based) and is also used in the reporting of qualitative data.
229 One survey was excluded as the participant reported on an e-alerting system at an NHS Trust not
230 included in the study, leaving a final sample of 101.

231

232

233

234

235

236 **Table 3:** Participant characteristics of interviews and survey

Characteristic	Interview participants	Survey respondents
Job grade	N (%)	N (%)
Foundation doctor year 1 (F1)	9 (31.0)	16 (15.8)
Foundation doctor year 2 (F2)	4 (13.8)	25 (24.8)
Specialty registrar doctor year 1/2 (ST1/2)	4 (13.8)	23 (22.8)
Specialty registrar doctor year 3/4/5 (ST3/4/5)	3 (10.3)	10 (9.9)
Specialty registrar doctor year 6/7 (ST6/7)	2 (6.9)	4 (4.0)
Staff grade doctor	0 (0)	5 (5.0)
Consultant	6 (20.7)	15 (14.9)
Nurse (band 6)	0 (0)	1 (1.0)
Other	1 (3.4)*	2 (1.0)†
NHS Trust	N (%)	N (%)
Trust 1	11 (37.9)	30 (29.4)
Trust 2	8 (27.6)	60 (58.8)
Trust 3	10 (34.5)	11 (10.8)
Department	N (%)	N (%)
Internal Medicine/Care of the Elderly	10 (34.5)	46 (45.5)
Emergency Admission	8 (27.6)	26 (25.7)
General / Vascular surgery	10 (34.5)	20 (19.8)
Other	1 (3.4)‡	9 (8.9)§

- 237 * Pharmacist
- 238 † Medical student=1, Locum Senior House Doctor=1
- 239 ‡ Pharmacy
- 240 § Palliative care=4, Acute medicine=2, Cardiology=1, ITU=1, Nephrology=1.

241
242 **Patient safety**

243 Overall patient safety culture, graded on a Likert scale from 1 (very poor) to 5 (excellent), had a mean
244 score of 3.75. A chi-square analysis comparing the three NHS Trusts identified no significant difference
245 in patient safety culture ($\chi^2=1.784$, $df=2$, $p=0.410$). Using the same method, there was also no
246 significant difference between the specialties surveyed ($\chi^2=1.453$, $df=3$, $p=0.693$). These results
247 indicated that different sites or specialties did not confound the analysis.

248
249 **Familiarity and perceived normalization**

250 Participants reported that they were mostly familiar with the e-alerts (mean=7.27, sd=2.562) and that
251 the e-alert was part of their normal work (mean=7.28, sd=2.649). However, it was reported that the
252 e-alerts would become a more normal part of their work (mean=8.32, sd=2.059), with a Wilcoxon
253 Signed Ranks Test confirming the difference was statistically significant ($Z=-5.049$, $p<0.001$),
254 suggesting that the e-alerts were not yet fully embedded.

255
256 **NPT mechanisms and sub-constructs**

257 Descriptive analysis of the mean scores of the four NPT mechanisms – coherence ($\bar{x}=72.3\%$), cognitive
258 participation ($\bar{x}=76.4\%$), collective action ($\bar{x}=66.5\%$) and reflexive monitoring ($\bar{x}=68.8\%$) – suggested
259 there was no key mechanism that led to (un)successful implementation of the e-alerts. Further

260 analysis of the 16 sub-constructs (table 1) identified several sub-constructs indicative of (un)successful
261 implementation; mean ratings for the 16 sub-constructs are presented in Figure 1. More specifically,
262 following triangulation with qualitative data, the NPT sub-constructs that were identified to contribute
263 to successful normalization of the AKI e-alerts were *internalization* and *legitimation*, and those that
264 contributed to unsuccessful normalization were *initiation*, *differentiation*, *skill set workability*, and
265 *systematization*. As with the survey data, there were no identified differences in qualitative findings
266 between the two e-alerting systems. Supporting qualitative data (quotes and field notes) for all sixteen
267 sub-constructs are provided in table 4. The remainder of the results will focus on NPT sub-constructs
268 that demonstrate where normalization was most positive or negative, based upon the triangulation
269 of all data sources, representing sub-constructs that most promote or inhibit use of AKI e-alerts in
270 secondary care.

271

272 **[Insert Figure 1 around here]**

273

274 **Sub-constructs demonstrating positive normalization**

275

276 ***Internalization***

277 Clinicians often reported that, despite not always utilising the AKI e-alert, they valued the potential of
278 it, which was reflected in the survey score of 4.16. This demonstrated that they had a fundamental
279 understanding of the importance of recognising AKI early, and many clinicians recognised that it was
280 possible to make mistakes and to miss AKI.

281

282 *“in something like renal function, where there’s so much variety, [the AKI e-alert] just*
283 *helps jolt you to it and especially how severe AKIs can be, it’s even more necessary*
284 *because hopefully things like that wouldn’t be missed, but there’s always the*
285 *potential that it could be. And having it say in black and white, this is an AKI, you*
286 *know, they shouldn’t be missed at all.” [F1 interview, Emergency Admissions, Trust*
287 *2]*

288

289 *“The times I think it’s probably useful is when it’s one of those slightly sneakier ones,*
290 *more subtle ones. The creatinine might have only peaked at 120 but, actually, if their*
291 *creatinine is normally 45, that’s still a big deal but it doesn’t jump out at you as a*
292 *creatinine of 600 would.” [Consultant interview, Internal Medicine/Care of the*
293 *Elderly, Trust 2]*

294

295 ***Legitimation***

296 Despite the lack of initiation (as identified in the Initiation theme), perceived or otherwise, clinicians
297 still largely understood that responding to the AKI e-alerts was their responsibility, though this
298 perspective was sometimes dependent on the clinician’s seniority. For instance, all clinicians
299 regardless of seniority recognised that the AKI e-alert was important to the work of junior doctors. In
300 particular, some senior staff (consultants and registrars) felt that junior staff did not place sufficient
301 priority on renal function; *“For [junior staff] it might make a difference because they might not look at*
302 *all the figures. If it says an AKI e-alert, then they might make the effort to actually do that” [ST6*
303 *interview, General/Vascular Surgery, Trust 3].* However, particularly on surgical wards where

304 foundation-year doctors were mostly responsible for ward-care of patients, the e-alerts were not seen
305 to be part of the senior doctor's role, even though the AKI e-alerts were still valued.

306

307 *"I think you'll find that as people progress, their focus of how they manage the patient*
308 *shifts. They're more interested in dealing with the active problems and these*
309 *outcomes of quite secondary issues that solve around the problem. The attitude is a*
310 *bit like mine: someone more junior will deal with it and you totally lose interest in the*
311 *other things."* [ST3 interview, General/Vascular Surgery, Trust 3]

312

313 **Sub-constructs demonstrating negative normalization**

314

315 ***Differentiation***

316 How clinicians differentiated the AKI e-alert from what was deemed to be normal practice prior to the
317 implementation of the AKI e-alert, was often based upon the length of time that the clinician had been
318 qualified. Clinicians who were newly qualified, particularly foundation-year doctors, consistently
319 reported that they had no experience of working without an e-alerting system, and so using the AKI
320 e-alert by default was deemed to be normal practice.

321

322 *"I suppose I haven't ever realised it's actually a new thing. Obviously, I've only worked*
323 *here 11 months, I just assumed it was always there"* [F1 interview, General/Vascular
324 Surgery, Trust 3]

325

326 Contrary to this, observations identified instances where clinicians were unaware of an e-alert for AKI,
327 or were unaware of how the e-alert should work. In the following extract from observation notes, the
328 clinician initially conceived of an e-alert as always being a pop-up, rather than text embedded into the
329 system.

330

331 *'I chat with [a doctor] and we talk about the AKI alerts. When I explain what it is I'm observing*
332 *for, he looks a bit confused, says he doesn't know about the alerts. He opens up a patient*
333 *record and explains he thinks this patient has AKI, so wants to see if there is an alert there.*
334 *After I describe what the alert should look like, he says he thought I meant "a pop-up rather*
335 *than a bit of text"; I think he doesn't see the text as an alert by itself.'* [Trust 3 observation of
336 Emergency Admissions, approx. 17:00]

337

338 Clinicians also identified that the lack of differentiation was related to the clinical area in which they
339 were working. For instance, it was deemed to be routine to check renal function of all patients entering
340 emergency admission suites. In this setting, clinicians often mentally risk-assessed patients for AKI.
341 For these patients, the clinicians would more regularly check to see if blood test results had been
342 returned.

343

344 *"At the moment, probably not an awful lot else than I would normally do. Normally if*
345 *I go through people's bloods specifically for renal function I usually click on each of*
346 *the numbers and compare it to what it has been previously. I think I interpret renal*
347 *function quite a lot in the context of what the patient's renal function IS? Or [sic]*
348 *usually like. I click on each of the five elements that we get reported here and then*

349 *have a look at how that varies from the previous. To be honest I would do that*
350 *irrespective of whether the alert is there or not.”* [ST1 interview, Emergency
351 Admissions, Trust 3]

352

353 **Initiation**

354 Initiation received a mean score of 2.8. This remained consistent across all three Trusts, and was
355 supported by interview participants who consistently reported that either the e-alerts *“just appeared*
356 *at some point”* [F1 interview, General/Vascular Surgery, Trust 3], or that the e-alerts were already
357 implemented when they began working for the Trust, as identified in the differentiation theme.
358 However, there was a key difference; even where alerts were already implemented and thus deemed
359 to be ‘normal’, there was a lack of training provided to clinicians on how to use the e-alerts. This
360 finding was consistent (and is partly duplicated) with the *skill set workability* sub-construct of NPT.

361

362 *“I think [the AKI e-alerts] just started popping up. So, we didn’t get any training or*
363 *anything like that on them, or why they were there, or who put them there, or what*
364 *the purpose was.”* [ST2 interview, Internal Medicine/Care of the Elderly, Trust 1]

365

366 In one Trust, the person who contributed to the implementation of the AKI e-alerts acknowledged this
367 sub-optimal initiation or training for doctors; *“When we first went live we switched the rules on but*
368 *we didn’t really do a lot of education, and I think [the alerts] were relatively unpopular”* [Pharmacist
369 interview, Trust 1]. Education consisted of an email with information about the AKI alerts to clinical
370 directors asking them to cascade it to their staff.

371

372 **Skill set workability**

373 The lack of training provided on how to use the e-alerts, as previously reported in the initiation theme,
374 also contributes to the skill set workability theme. Participants reported that they generally had
375 responsibility for AKI and thus the e-alerts, demonstrating to an extent that that there was appropriate
376 skill set workability amongst those receiving the e-alerts. However, there were also occasions where
377 participants demonstrated or recognised their own lack of knowledge related to the AKI e-alerts such
378 as incorrectly describing how they thought the e-alerts worked. More specifically, participants
379 regularly did not know how the e-alerts should be incorporated into their own practice.

380

381 *“A teaching session would be really good of explaining, like, how to use the alert, like,*
382 *the situations when the alert isn't effective and, then, just, kind of, what to do if you*
383 *do get an alert.”* [Consultant interview, Internal Medicine/Care of the Elderly, Trust
384 2]

385

386 **Systematization**

387 Across all three of the NHS Trusts, no participants (regardless of seniority) collected information on
388 the effectiveness of the AKI e-alert. While the data collected did not indicate whether anyone in the
389 Trusts collected information regarding the effectiveness of the AKI e-alerts, it was consistently
390 reported by all interview participants that feedback was not given to those using the AKI e-alerts.
391 Furthermore, participants were unaware of whether the AKI e-alert, or more specifically responding
392 to the AKI e-alert, had any effect.

393

394 *"I think maybe a bit of feedback or a bit of education [would help staff to engage with*
 395 *the AKI alert. So, feedback as to how things had changed since the alert was*
 396 *introduced. [...] Some sort of outcome measure would be quite interesting. That*
 397 *might, just to show people that it's actually having a benefit."* [Consultant interview,
 398 Internal Medicine/Care of the Elderly, Trust 1]
 399

400 **Table 4:** Summary of the qualitative framework analysis for the 16 NPT sub-constructs with
 401 supportive evidence

NPT mechanisms and sub-constructs	Coding summary	Supporting evidence
Coherence		
Differentiation <i>Mean survey score: 3.18</i>	Clinicians often did not differentiate between normal practice and use of the AKI e-alert; checking the patient's renal function was deemed to be routine in the clinical areas studied.	<i>'A doctor says that it's a routine part of their job to check renal function and would check it anyway – this is the case even in the emergency department if a patient came in with a broken arm to check for a potential underlying condition'</i> [Trust 1 observation of Emergency Admissions, approx. 19:30]
Communal specification <i>Mean survey score: 3.29</i>	Working with the AKI e-alert was perceived to be an individual rather than team action. The e-alert was rarely discussed or used to initiate discussion, with staff often not knowing what others thought about the e-alert.	<i>"I don't think we've had much discussion about the AKI alerts, it's certainly not something that I'm aware of, that other people have commented on."</i> [F1 interview, General/Vascular Surgery, Trust 2] <i>"I haven't spoken to anyone else [about the AKI e-alert]. I know just from being in the doctor's office, with the other doctors that sometimes, you know, you see people glance at the screen, and go 'click' whilst they are still talking to you."</i> [ST2 interview, Internal Medicine/Care of the Elderly, Trust 2]
Individual specification <i>Mean survey score: 3.8</i>	AKI e-alerts often made staff consider the patient's AKI and to double check renal function.	<i>"I guess it's to draw attention to it quickly rather than bloods getting lost in the system for the day, because... especially on a busy ward [...] there'll be... I don't know... 20 bloods sent in the morning and then if you're busy with sick people it could go well into the afternoon before you get to check on bloods."</i> [F1 interview, Emergency Admissions, Trust 2]
Internalization <i>Mean survey score: 4.16</i>	Many staff saw the potential value of the AKI e-alert and understood the need for the e-alerts.	<i>"I think it's probably the most useful out of the alerts. It generally comes on when the patients genuinely do have an AKI, although, that's often sometimes not the case. Like we said before, often it does require action, so, yes, they're pretty useful."</i> [F1 interview, Emergency Admissions, Trust 1]
Cognitive participation		
Initiation <i>Mean survey score: 2.8</i>	Participants frequently cited a lack of initiation in relation to the AKI e-alerts. This occurred for one of two reasons; 1) the e-alerts just appeared without any training on how to use them, or 2) clinicians were newly qualified (or new to the Trust) and the e-alerts were already implemented, but again no was training provided.	<i>"Yes they just sort of bob up. We never had really any induction about them"</i> [F1 interview, General/Vascular Surgery, Trust 3]
Legitimation	For the more junior doctors, the e-alerts are perceived to be a legitimate	<i>"we have specialist nurses who provide input for absolutely everything. So, the idea that there isn't</i>

<p>Mean survey score: 4.16</p>	<p>part of their role. However for more senior doctors, particularly in surgical units, the e-alerts were a useful intervention but only for junior doctors. Some clinicians felt that there should be a specialist AKI nurse.</p>	<p><i>one for an AKI, is a bit silly, in my opinion. Because, somebody coming... their purpose in my opinion would be to come around, read what they are in for, review their pathology, review the patient, and review reversible factors. Then make a recommendation to the junior and the consultant about reversible factors that hadn't been looked at yet."</i> [ST1 interview, Internal Medicine/Care of the Elderly, Trust 2]</p>
<p>Enrolment Mean survey score: 4.24</p>	<p>As working with the AKI e-alert was an individual action, it often had no influence on working relationships. For the few clinicians who saw the relational value, it was beneficial by providing the AKI stage that could be easily reported.</p>	<p><i>"if one of the F1's came to me and said, 'this woman's creatinine has gone up', then yes, absolutely we would have a chat about meds, and fluid, and have they had an ultrasound scan, and what do you think we should do? But, I don't think the alert has ever prompted me to do that"</i> [ST2 interview, Internal Medicine/Care of the Elderly, Trust 1]</p> <p><i>"It's good if you're doing a handover on the phone or something or talking to seniors in critical care or other hospitals. You can say this is Stage 2 AKI and that is sort of a standard term that people do understand even if we don't use it in general day-to-day discussion in the notes as much as we should do."</i> [F1 interview, General/Vascular Surgery, Trust 3]</p>
<p>Activation Mean survey score: 4.06</p>	<p>Prolonged exposure to the AKI e-alerts impacted upon clinician's support for them; the e-alerts had more impact when new, but they became part of the milieu and lost amongst other e-alerts or working practices.</p>	<p><i>"Yes, I do actually. I think it's a big component of patient safety and I think it is the direction of travel of where we're going. As time goes on, looking forward, I think we're going to expect more and more of these alerts related to algorithms and severity."</i> [Consultant interview, Emergency Admissions, Trust 1]</p>
<p>Collective action</p>		
<p>Interactional workability Mean survey score: 3.98</p>	<p>It was generally deemed easy to integrate the AKI e-alerts into normal working practices; they are there as a 'check' or 'backup' as most clinicians were routinely checking renal function. The e-alerts were perceived to speed up the process of calculating the stage of AKI. E-alerts were seen to be useful where Creatinine was within normal range, but with an increase of >1.5 from baseline.</p>	<p><i>"I think if it's not someone I already know, then yes, the alerts at least make me glance at the U&Es, which I would do anyway, but you know, just an extra reminder to check back what their previous U&Es were."</i> [ST7 interview, Emergency Admissions, Trust 1]</p> <p><i>"I think in some ways, it probably does speed things up, because you have got that alert there, and I think, when you open up a page of bloods, and it's quite obvious, and the first thing you see is they have an AKI."</i> [ST3 interview, Emergency Admissions, Trust 3]</p>
<p>Relational integration Mean survey score: 3.67</p>	<p>The AKI e-alert did not appear to affect working relationships. Staff mostly do not refer to the e-alert when discussing AKI, and AKI care is often an isolated task. An exception is stage 3 e-alerts, which sometimes trigger discussions with renal services.</p>	<p><i>"I don't know about the other staff and how they engage because actually I've not had a lot of feedback from them. I haven't actually been hearing the juniors saying, 'Oh there was an AKI alert' on anyone so I suspect most of them are just clicking and moving on, dismissing and moving on because they probably already know what the creatinine's doing."</i> [Consultant interview, General/Vascular Surgery, Trust 1]</p>

<p>Skill set workability Mean survey score: 3.27</p>	<p>There was a lack of training on how to best use the AKI e-alerts (also reported in <i>initiation</i>), and some clinicians demonstrated a lack of understanding about AKI, particularly the meaning of the different stages.</p>	<p><i>“when you come to the Trust you get- I don't know how long the sessions are and I don't know what they cover, and I don't know whether they cover alerts and things like that. If they do have [AKI e-alert training], I suspect it comes at the end of a very long day of induction where they've been told about every single problem under the sun and they've probably switched off.”</i> [ST7 interview, Emergency Admissions, Trust 1]</p> <p><i>“And there's [AKI stages] 1, 2 and 3, I can't really remember the difference between the three of them but if it flags up something I go, 'oh, okay, there's something different here.’”</i> [F1 interview, General/Vascular Surgery, Trust 3]</p>
<p>Contextual integration Mean survey score: 3.32</p>	<p>Clinicians did not report any specific resource requirements for the AKI e-alert other than training and time. Management support (where considered in the capacity of those responsible for e-alerts; the laboratory) was not identified by participants.</p>	<p><i>“I've no idea [who has responsibility for the AKI e-alerts], no. I assume somebody will do but I don't know, it's not been communicated.”</i> [F1 interview, General/Vascular Surgery, Trust 3]</p>
<p>Reflexive monitoring</p>		
<p>Systematisation Mean survey score: 2.5</p>	<p>Feedback was never provided to staff on the effect of the AKI e-alert.</p>	<p><i>“I haven't had any feedback since the new version [of the AKI e-alert] went in actually [...] I don't know whether there is a formal mechanism for that getting to anyone.”</i> [Pharmacist interview, Trust 1]</p>
<p>Communal appraisal Mean survey score: 3.39</p>	<p>The e-alert was rarely (if ever) discussed amongst clinicians, but participants often stated they felt that others would find it worthwhile.</p>	<p><i>“Most people I'm sure would know it's a good idea having them. That's what I'd say to someone about these alerts.”</i> [Consultant interview, Emergency Admissions, Trust 1]</p>
<p>Individual appraisal Mean survey score: 3.52</p>	<p>Whilst a small minority of clinicians felt the AKI e-alert had no effect on their work, many did but placed the effect within constraints relating to edge-case scenarios where AKI was most likely to be missed. These included marginal AKI thresholds within 'normal Cr range', busy workloads, and AKI presenting in CKD patients. The pop-up e-alert was sometimes perceived to be intrusive, whilst the passive e-alert was often described as being too easy to dismiss.</p>	<p><i>“Speaking to a doctor, they felt that the AKI alerts are very useful. He says that if he sees an alert then he'll check the patient's renal function. He also explains that things at handover will often get missed so doesn't always know that the patient will have an AKI”</i> [Trust 1 observation of Emergency Admissions, approx. 19:45]</p>
<p>Reconfiguration Mean survey score: 3.89</p>	<p>Clinicians often did not know who was responsible for the AKI e-alert. They would never consider providing feedback about the e-alert, and there was no formal mechanism for doing so.</p>	<p><i>“I'm not sure if there is a feedback mechanism. If there is, I'm not aware of it.”</i> [F1 interview, Emergency Admissions, Trust 1]</p> <p><i>“[To provide feedback] I would ring IT and they would probably be very unhelpful and I would give up at that point.”</i> [ST2 interview, Internal Medicine/Care of the Elderly, Trust 1]</p>

403 **DISCUSSION**

404 This is the first known mixed methods study to use Normalization Process Theory to investigate the
405 implementation of AKI e-alerts,¹⁷ an area identified as being an international research priority.⁹ The
406 findings of this study suggest that AKI e-alerts are somewhat embedded into routine practice in the
407 English NHS Trusts studied, with several aspects of implementation indicative of positive or negative
408 normalization. Given AKI e-alerts are now mandated across primary and secondary care in England
409 and Wales,⁴ these findings suggest that more consideration was needed for how the AKI e-alert could
410 be integrated into existing healthcare processes to influence both individual and collective behaviours.
411 Furthermore, the findings highlight how other healthcare systems, where AKI e-alerts are not
412 mandated, could implement AKI e-alerts in the future to improve their use.

413
414 The two aspects that particularly promoted normalization of the AKI e-alert were that the e-alert was
415 seen to be a legitimate part of a clinician's role, and clinicians within the study mostly recognised the
416 potential benefits of using the AKI e-alert. This demonstrates insight amongst clinicians that AKI is a
417 significant risk to patient safety,² and consequently clinicians understand the importance of early AKI
418 detection and treatment,²⁸ which have been historically poor.³ This finding also suggests that, when
419 operated raising awareness of AKI and AKI e-alerting is insufficient, when operated as a single
420 strategy, in addressing the problem of poor AKI care. Instead, attention should focus on other aspects
421 of implementation that could be improved.

422
423 One such aspect that required improving was initiation to the e-alerts, such as via Trust-specific
424 training, which was lacking or of insufficient quality. This was demonstrated by a lack of knowledge
425 amongst clinicians about what differentiates the stages of AKI, and how the e-alerts were expected to
426 be used. The definition of AKI has been refined considerably over the past decade, partly in an attempt
427 to reduce variation in practice,^{6,29} but our findings reflect previous studies which have identified gaps
428 in AKI knowledge amongst medical staff.³⁰ Although education is important in improving AKI care,⁷
429 there is a gap between the objective volume of delivery of AKI teaching and end-users' perception of
430 its paucity.³⁰ This dissonance might also be consistent with an alternative interpretation to our
431 findings, which is that the existing definition of AKI lacks intuition and/or clinical credibility. Clinicians
432 in our study reported using the terms minor, moderate, or severe, even when they knew the different
433 stages as per the 2012 KDIGO guidelines⁶ as they felt it easier to communicate to others. This
434 corresponds closely with our finding, that some clinicians had difficulty in recognising and prioritising
435 AKI e-alerts. Little research has focussed on how staff are educated about AKI e-alerts, but some
436 tentative links have been made between effective education and successful implementation.³¹

437
438 Another area of implementation identified as needing improvement was the systematization of the
439 AKI e-alerts through implementing feedback to end-users of the e-alerts. There was no system for
440 providing feedback to clinicians, despite a wide range of safety literature identifying the importance
441 of providing this to people involved in the process.³²⁻³⁴ NPT proposes that an intervention is normalized
442 through agents' continuous actions which are enacted over a sustained period of time and space.³⁵ As
443 approval ratings for AKI e-alerts have been reported to reduce over time, giving feedback to those
444 involved in the safety behaviour could slow, pause or even reverse the decline,^{36,37} and can be a
445 transformative process that can lead to improved performance.³⁸

446

447 Alert fatigue or disruptions to workflow have been identified as barriers to implementation,^{5,10} and
448 there were examples of these identified in this study. Both e-alert systems produced opposing
449 perspectives on how or whether the e-alerts influenced workflow. It was however common for those
450 receiving the pop-up e-alert to dismiss it instantly and comment on its intrusiveness, whilst those who
451 received the passive e-alert commented on it not being intrusive enough and being too easy to ignore.
452 This suggests that there is no one-size-fits-all e-alert presentation, and instead they may require
453 tailoring to either the individual or clinical unit. However, the causes of these differing perspectives
454 were unclear and require further research.

455

456 It was also notable that collaborative working in response to the AKI e-alert were dismissed or
457 downplayed by participants. Implementation of a complex intervention, or of a simple intervention
458 into a complex environment, requires social activity that results in joint action; agents' continuous
459 actions are enacted over a sustained period of time and space.³⁵ Using and incorporating the e-alert
460 into practice was often perceived to be an individual action that did not result in or alter discussions
461 amongst clinicians. Future research should investigate whether the individual nature of an
462 intervention, such as AKI e-alerting, contributes to poorer implementation, and whether such
463 interventions require more collaborative working to be built-in to improve optimality.

464

465 **Limitations**

466 Firstly, the study was conducted in clinical areas where AKI incidence is high, which may limit the
467 generalisability of the findings; it is unknown whether the e-alert would be more useful (and whether
468 it would be more or less poorly implemented) in clinical areas where AKI incidence is lower and thus
469 clinicians have lower contact time with the AKI e-alert. Secondly, the study was conducted in one
470 region, and so implementation of the AKI e-alert may have been influenced by local networks. Finally,
471 it is unknown whether the e-alerts had a quantifiable impact on AKI outcomes or staff actions, and so
472 it is not possible to draw conclusions about the effectiveness of the AKI e-alerts studied as a result of
473 implementation. However, the identification of perceived differences between the NPT mechanisms,
474 including sub-constructs that were successfully implemented, suggests that a more focused approach,
475 aligned with Safety-II principles, could help to identify successful implementation. Investigating where
476 AKI e-alerts have been successfully implemented on a larger scale would provide valuable lessons for
477 future implementation of both AKI e-alerts and other e-alerts.

478

479 **CONCLUSIONS**

480 Clinicians recognised the value and importance of AKI e-alerts in their clinical practice, though not
481 sufficiently for AKI e-alerts to be routinely engaged with. To further normalize and promote clinician
482 engagement with AKI e-alerting systems, there is a need for tailored training on AKI and how to use e-
483 alerts; feedback should, also, be routinely given to staff about their impact on outcomes. The findings
484 of this study provide a potential explanation for conflicting data on the reported effectiveness of AKI
485 e-alerting systems. The findings have the potential to inform future national improvements to the way
486 in which AKI e-alerts are implemented in the NHS and could be transferred into other countries'
487 healthcare systems where AKI e-alerts have either not yet been implemented or where this has been
488 suboptimal.

489

490

491 **Declarations**

492 ***Ethical approval and consent to participate***

493 All participants provided informed consent to participate. Interview participants provided written
494 consent. Consent for observations was provided verbally by the lead consultant of each unit and
495 individuals being observed. Survey respondents provided consent by returning the survey. The project
496 was reviewed and Approved by the National Health Service's Health Research Authority
497 (<https://www.hra.nhs.uk/>) [reference 16/HRA/2106]. HRA Approval brings together the HRA's
498 assessment of governance and legal compliance with the independent ethical opinion by a Research
499 Ethics Committee. HRA Approval is for all project based research involving the NHS and Health and
500 Social Care that is being led from England.

501

502 ***Consent for publication***

503 Not applicable

504

505 ***Availability of data and materials***

506 The quantitative datasets used and/or analysed during the current study are available from the
507 corresponding author on reasonable request. Participants were not asked to provide consent to
508 share their transcripts beyond the research team. The study team would be happy to interrogate the
509 data on behalf of others upon reasonable request to the corresponding author.

510

511 ***Competing interests***

512 NSS received travel funding from Alexion Pharmaceuticals to attend ERA-EDTA 2018 congress. NSS is
513 also a grant holder for a project 'Imaging in Chronic Kidney Disease', funded by GlaxoSmithKline. No
514 other authors have competing interests to declare.

515

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519 collection, management, analysis, interpretation of the data, preparation, review or approval of the
520 manuscript, and decision to submit the manuscript for publication.

521

522 ***Author contributions***

523 TF, MB, GM, CB, BY, NK, NSS, NSK conceived and designed the study. JS collected the data. JS, TF,
524 GM and NSK analysed the data. JS and NSK drafted the manuscript, with all authors providing critical
525 revisions and approval for the final version. JS and NSK agree to be accountable for all aspects of the
526 work.

527

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531

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630 **Figure title & legend**

631 Figure 1 title: Petal chart showing mean scores for the sixteen NPT sub-constructs

632 Figure 1 legend: Likert scale of 1 (strongly disagree) to 5 (strongly agree).

Sample N,18.0117285.Q (BLOOD) Collected 29 Jul 2018 22:36 Received 29 Jul 2018 23:06

U&E

Sodium		137	mmol/L	133 - 146
Potassium		4.4	mmol/L	3.5 - 5.3
Chloride		108	mmol/L	95 - 108
Bicarbonate	*	21	mmol/L	22 - 29
Urea	*	8.6	mmol/L	2.5 - 7.8
Enzymatic Creatinine	*	203	umol/L	49 - 90

***** AKI STAGE 2 *****

Please refer to Trust AKI guideline on Intranet



Possible Acute Kidney Injury

██████████'s Cr has been rising at ≥ 25 $\mu\text{mol/L/day}$ when normalised over 24 hours.

The absolute Cr rise may be small if checked frequently - use clinical judgement

Creatinine: is 120 as of 08 August, 2014 15:59:00 BST

Creatinine: is 98 as of 08 August, 2014 15:58:00 BST

To get further advice or stop alerts, click on **MORE INFO**, below. Otherwise, click on **DISMISS** to continue

[MORE INFO](#)

[DISMISS](#)

Acute Kidney Injury Alert Study

Interview Questions

Themes:

- **Coherence:** Meaning-making sense of the technology and the work, differentiation, embedding
- **Cognitive participation:** Commitment-what is done to work with others
- **Collective action:** Effort-what is done whilst using this tool
- **Reflexive monitoring:** Comprehension- How the new technology affects them, others and patient care

Introduction

- Introduce myself and my role in the research
- Ensure information has been read and consent (x2) is signed and they retain a copy
- Ask the participant to briefly explain:
 - Who they are
 - What they do (role) e.g. Dr (registrar etc.) nurse.
 - How long they have been on the ward
 - What other experience do they have, eg previous roles

Opening question

- Q** Please describe your first/last encounter with the AKI alerts: this should provide a basis for further questions as it will point to aspects of his or her experience
 - What sort of experience do you have of using AKI alerts?
- Q** How do you currently use electronic alerts (not necessarily AKI) within the electronic record? Are some alerts more important than others? (if yes, what makes them so?)
- Q** Use screen prints of each page to ask questions about user experience: ease of use, visual appearance, nuisance factors etc.
 - If appropriate make memos of facial expressions, hand gestures, non-verbals
 - Make memos in relation to comments for further questioning/investigation at the interview and/or subsequent participants.

List of potential (Not in order of importance) Normalization Process Theory-based questions as a reminder used on the basis of answers to the opening questions

Many descriptive and explanatory questions are used to elicit detail of actions, processes, outcomes and correlations. Some questions may overlap one or more theme.

Questions will develop given the kind of answer and may include questions not cited below.

Coherence Type Questions

- Q** What do you understand as the purpose of the alerting tool? Is it important to the patient's safety? Why do you think the alerts have been implemented?
- Q** Ideally, where do you think this tool should fit in to your daily work?

- Q How do others in your unit / clinical setting use the tool? From your own experience, is this specific to your clinical setting?
- Q From your perspective, how do AKI alerts compare to other alerts / computer tools
- Q How do you think you are expected to use the alert?
- Q What benefits/value do you think the alert provides?

Cognitive Participation type questions

- Q Who leads the use of this on your ward/unit? What does this role / task consist of for them? Does it include responsibility for AKI outcomes?
- Q How do the different professionals on the ward interact / use / respond to the alert? Do people have different roles / interactions with the alert depending on their profession / role?
- Q From your perspective, what would help staff to engage better with the alerting system?
- Q Have you shown others how to use it? If so, describe what you did and why. If not, why not?

Collective Action type questions

- Q Please describe what you do when you encounter the alert?
- Q Please explain how the tool helps/hinders working with others
- Q How does the alert affect how you work? Eg use of time and resources

Reflexive monitoring

- Q How does it make you feel when you see the alert?
- Q Would you say the alert is useful or not? Explain
- Q What do you think of the alert? (elicit a personal opinion)
- Q What do others say about it?
- Q To what extent do you and/or others have the ability to provide feedback / influence improvements to the system? What helps or hinders this ability?
- Q Has it altered the way you work/think about acute kidney injury?
- Q Does the alert effect change in medical management of the patient? Does this lead to a change in the patient's outcome?
- Q Is the alert worthwhile? Explain the answer
- Q Are there any improvements you would like to make to the system? Eg alert, interaction with alerts, validation, visual etc.

Remember to thank them for their time and effort

Survey Instructions

This survey is designed to help get a better understanding of how to apply and integrate new technologies and complex interventions in health care.

This survey asks questions about the implementation of acute kidney injury (AKI) electronic alerts into patients' medical records. We understand that people involved with AKI alerts have different roles, and that people may have more than one role. For this survey, please answer all the statements from the perspective of being an end-user of AKI alerts.

The survey is in 3 parts, Parts A-C:

- Part A asks some brief questions about yourself and your role.
- Part B asks general questions about patient safety and AKI alerts.
- Part C contains four sets of statements about AKI alerts. For each statement in Part C, there is the option to agree or disagree with what is being asked. However, if you feel that the statement is not relevant to you, you can answer 'not relevant'.

The survey is on both sides of paper. Answers to all questions are required, except where it is stated as being optional. The only optional questions are Q15b, Q16b, Q17b, and Q18b.

Please take the time to decide which answer best suits your experience for each statement and tick the appropriate circle.

If you would like to complete this version electronically (on mobile, tablet or desktop) please use the address below.

[\[address removed for publication\]](#)

Electronic alerts for acute kidney injury – end user survey

Part A: About yourself

Survey number
(admin only)

Q1. How would you describe your professional job category?

- Medical doctor (*go to Q2a*)
- Surgical doctor (*go to Q2a*)
- Nurse (*go to Q2b*)
- Other (*go to Q2c*)

Q2a. How would you describe your professional job level?

- Foundation-years doctor 1 (F1)
- Foundation-years doctor 2 (F2)
- Specialist trainee doctor (ST1 or ST2)
- Specialist trainee doctor (ST3, ST4 or ST5)
- Specialist trainee doctor (ST6 or ST7)
- Staff grade doctor
- Consultant
- Other (*go to Q2d*)

Please go to question 3 on the next page

Q2b. How would you describe your professional job level?

- Band 4
- Band 5
- Band 6
- Band 7
- Band 8a
- Band 8b
- Band 8c
- Other (*go to Q2d*)

Please go to question 3 on the next page

Q2c. How would you describe your professional job category? For example healthcare assistant, nurse, doctor.

Please go to question 2d below

Q2d. How would you describe your professional job level? For example, your current grade / band

Please go to question 3 on the next page

Part A: About yourself (continued)

Q3. How many full years have you held your primary professional qualification?

Q4. Which NHS Trust do you currently work at?

- Gateshead Health NHS Foundation Trust
- Newcastle upon Tyne Hospitals NHS Foundation Trust
- Northumbria Healthcare NHS Foundation Trust
- Other (please specify in box below)

Q5. How many full years have you worked in your current role at this NHS Trust?

If your Trust has merged with another or changed its name, please include in your answer all the time you have worked with this Trust and its predecessors

Q6. Which best describes the department / unit that you work in?

- Internal Medicine / Care of the Elderly
- Emergency Admissions
- General / Vascular Surgery
- Other (please specify)

Q7. How many full years have you worked in your current role in this department / unit?

Part A: About yourself (continued)

Q8. Have you received any formal or informal training in relation to acute kidney injury in the past 24 months?

- No
- Yes (please specify)

Q9. Does your team, unit or NHS Trust have any initiatives other than acute kidney injury electronic alerts to improve acute kidney injury awareness?

- No
- Yes (please specify)

This is the end of Part A. Please turn over for Part B.

Part B: General questions about patient safety

Q10. Perceptions of patient safety in your work area / unit

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
It is just by chance that more serious mistakes do not happen around here	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Patient safety is never sacrificed to get more work done	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We have patient safety problems in this unit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Our procedures and systems are good at preventing errors from happening	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q11. Please give your work area / unit in this hospital an overall grade on patient safety

	Failing	Poor	Acceptable	Very good	Excellent
Patient safety grade	<input type="radio"/>				

Part B: General questions about acute kidney injury alerts

Q12. When you see an acute kidney injury alert within the patient's record, how familiar does it feel?

	Still feels very new									Feels completely familiar
	1	2	3	4	5	6	7	8	9	10
Familiarity of AKI alert	<input type="radio"/>									

Q13. Do you feel the acute kidney injury alert is currently a normal part of your work?

	Not at all									Completely
	1	2	3	4	5	6	7	8	9	10
Responding to the AKI alert is currently normal (present)	<input type="radio"/>									

Q14. Do you feel the acute kidney injury alert will become a normal part of your work?

	Not at all									Completely
	1	2	3	4	5	6	7	8	9	10
Responding to the AKI alert will become normal (future)	<input type="radio"/>									

This is the end of Part B. Please turn over for Part C1.

Part C1: Detailed questions about acute kidney injury alerts

Q15a. For each statement, please select one answer that best suits your experience.

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Not relevant
I can see how the AKI alert differs from usual ways of working	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Staff in this organisation have a shared understanding of the purpose of the AKI alert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I understand how the AKI alert affects the nature of my own work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I can see the potential value of the AKI alert for my work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q15b. Please elaborate on your answers provided in this part (optional)

This is the end of Part C1. Please turn over for Part C2.

Part C2: Detailed questions about acute kidney injury alerts (continued)

Q16a. For each statement, please select one answer that best suits your experience.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Not relevant
There are key people who drive the AKI alert forward and get others involved	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I believe that responding to the AKI alert is a legitimate part of my role	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I'm open to working with colleagues in new ways when responding to the AKI alert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I will continue to support the AKI alert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q16b. Please elaborate on your answers provided in this part (optional)

This is the end of Part C2. Please turn over for Part C3.

Part C3: Detailed questions about acute kidney injury alerts (continued)

Q17a. For each statement, please select one answer that best suits your experience.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Not relevant
I can easily integrate the AKI alert into my existing work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The AKI alert disrupts working relationships	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have confidence in other people's ability to respond to the AKI alert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Work is assigned to those with skills appropriate to responding to the AKI alert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sufficient training is provided to enable staff to implement the AKI alert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sufficient resources are available for the AKI alert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Management adequately supports the AKI alert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q17b. Please elaborate on your answers provided in this part (optional)

This is the end of Part C3. Please turn over for Part C4.

Part C4: Detailed questions about acute kidney injury alerts

Q18a. For each statement, please select one answer that best suits your experience.

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Not relevant
I am aware of reports about the effects of the AKI alert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The staff agree that the AKI alert is worthwhile	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I value the effects that the AKI alert has had on my work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feedback about the AKI alert can be used to improve it in the future	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I can modify how I work with the AKI alert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q18b. Please elaborate on your answers provided in this part (optional)

Please turn over

This is the end of the survey

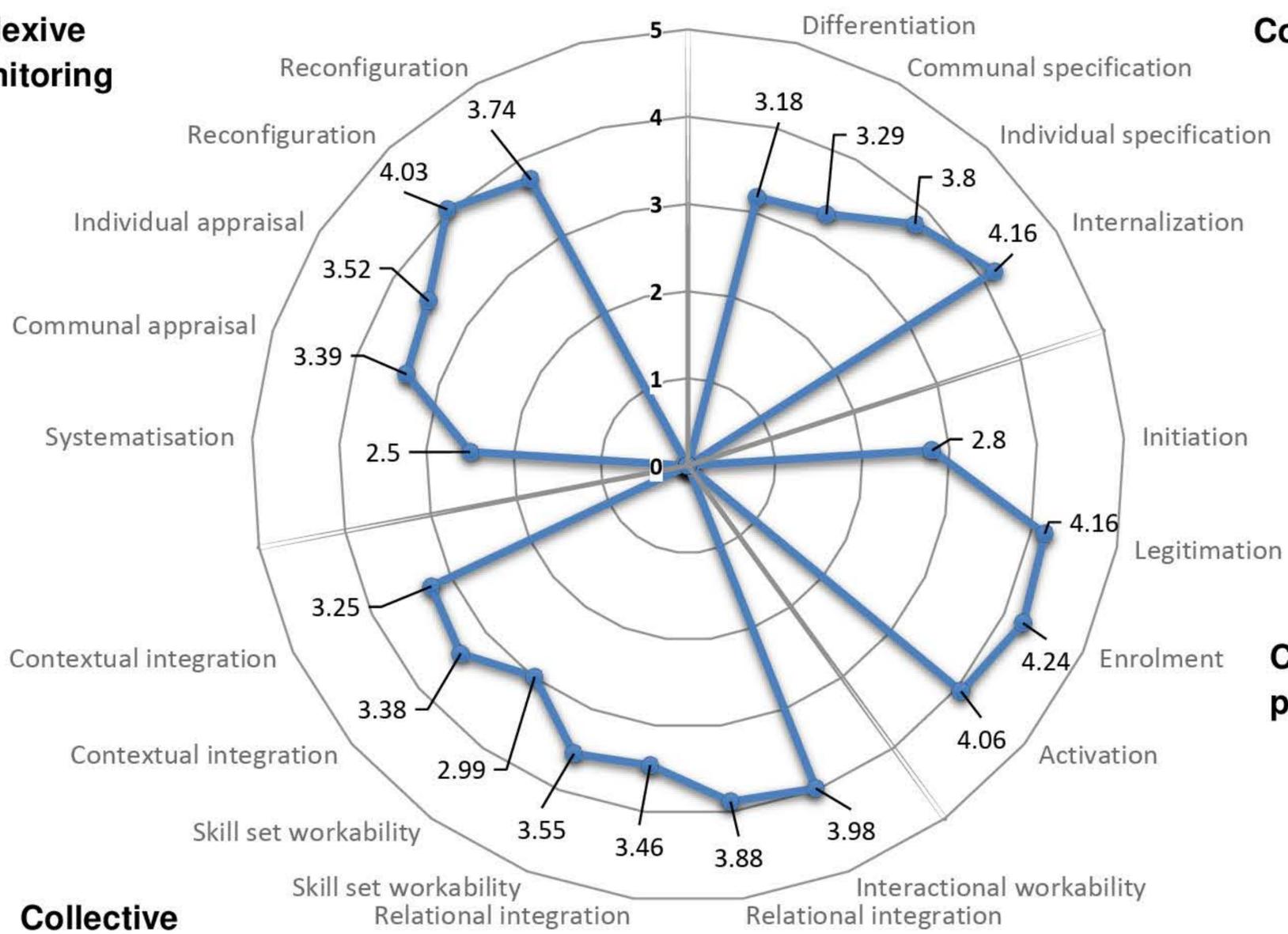
Thank you for completing the survey; your participation is greatly appreciated. We understand that the nature of a survey may not allow you to fully express your thoughts and opinions about the acute kidney injury alerts. If you feel this is the case and would be interested in participating in an interview (if you have not already), please leave your name and email address below and we will be in touch shortly with more information. These will not be linked back to your survey responses. If you are not interested in hearing more about an interview, please leave the box blank.

Name

Email address

Reflexive monitoring

Coherence



Cognitive participation

Collective action