Clinical decisions and time since rest break: An analysis of decision fatigue in nurses

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ABSTRACT

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Objective: The present study investigates whether nurses working for a national medical telephone helpline show evidence of 'decision fatigue', as measured by a shift from effortful to easier and more conservative decisions as the time since their last rest break increases.

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Methods: In an observational, repeated-measures study, data from ~4,000 calls to 150 nurses working for the Scottish NHS 24 medical helpline (37% of the national workforce) were modelled to determine whether the likelihood of a nurse deciding to refer a patient to another health professional the same day (the clinically safest, but most conservative and resource inefficient decision) varied according to the number of calls taken/time elapsed since a nurse's last rest break and/or since the start of shift. Analyses used mixed-effect logistic regression.

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Results: For every consecutive call taken since last rest break, the odds of nurses making a conservative management decision (i.e. arranging for callers to see another health professional the same day), increased by 5.5% (p=.001, 95% CI: 2.2%, 8.8%), an increase in odds of 20.5% per work hour (p<.001, 95% CI: 9.1%, 33.2%) or 49.0% (on average) from immediately after one break to immediately before the next. Decision making was not significantly related to general or cumulative workload (calls or time elapsed since start of shift).

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73 **Conclusions**: Every consecutive decision that nurses make since their last

74 break produces a predictable shift towards more conservative, and less

75 resource efficient decisions. Theoretical models of cognitive fatigue can

76 elucidate how and why this shift occurs, helping to identify potentially

77 modifiable determinants of patient care.

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83 **INTRODUCTION**

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86 *"We think, each of us, that we're much more rational than we are. And we*

87 *think that we make our decisions because we have good reasons to make*

88 *them."* Daniel Kahneman (2012)

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91 In order to make decisions about patients, health professionals must take in

92 and weigh up relevant information and make a choice about the most

93 appropriate course of action to take. While it is tempting to believe that the

94 decisions of health professionals are based entirely on logic and a balanced

95 weighing of the information available, human decision-making is susceptible

96 to a wide range of individual, social and environmental influences. In a highly-

97 cited study of judicial decisions, Danziger, Levav and Avnaim-Pesso (2011)

98 studied the parole decisions of court judges over the course of the working

99 day. While the probability of a judge deciding to release a prisoner on parole

100 at the beginning of the day was ~65%, this fell steadily to nearly 0% as time

101 since the start of the court session wore on, returning to ~65% after a

102 food/rest break and again falling steadily to 0% towards the end of the day.

103   The pattern reported fits with the psychological phenomenon '*decision*

104 *fatigue'*: a state occurring when mental resources become depleted and/or

105 when motivation to exert mental effort declines over time resulting in a

106 measurable shift towards easier, safer, or more gratifying decisions and

107 actions (Pignatiello, Martin & Hickman, 2018). In the judge's case, the 'safest'

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108   and therefore mentally easiest option was to maintain the status quo (denying

109   parole); the more depleted judges became, the more likely they were to select

110   this conservative option until an opportunity arose (in the form of a break) to

111   rest and replenish their resources. Since its publication, re-analyses of the

112   original data and data simulation studies have suggested that non-random

113   ordering of cases before judges and/or explicit planning of cases around

114   breaks is likely to explain some or all of the observed effects (Weinshall-

115   Margel & Shapard, 2011; Glockner, 2016). However, the decision fatigue

116   phenomenon has been observed in multiple contexts where such factors are

117   less likely to be an issue.

118   Exertion-based depletion effects were first observed more than a

119   century ago with Arai (1912) noting in a study of continuous work over time

120   that "…..continued work brings about a decrease in the efficiency of the

121   [mental] function exercised" (p. 114). Depletion effects are evident in a wide

122   range of contexts with people being, for example, more likely to cheat at

123   effortful tasks late in the day (Kouchaki & Smith, 2014), more likely to give up

124   on diets at the end of the day (McKee, Ntoumani & Taylor, 2014), more likely

125   to accept default options at the end of a series of consecutive decisions

126   (Levav, Heitmann, Hermann & Iyengar, 2010) and less able to perform well on

127   cognitive tests later in the day (Sievertsen, Gino & Piovesan, 2016). Within

128   the healthcare context, compliance with hand hygiene protocols declines

129   predictably from the start to the end of shifts (Dai, Milkman, Hofmann &

130   Staats, 2015; Chudleigh, Fletcher & Gould, 2005), gastorenterologists are

131   more likely to detect polyps during morning than afternoon colonoscopies

132   (Chan, Cohen, & Spiegel, 2009), and doctors prescribe more unnecessary

133   antibiotics towards the end than the start of clinic sessions (Linder, Doctor,

134   Friedberg, Reyes Nieva, Birks, Meeker & Fox, 2014).

135   These decision fatigue effects have been primarily conceptualized as

136   either the result of 'ego depletion', that is a decrease in the availability of the

137   mental resources required to exert effortful self-control (Baumeister,

138   Pratlavsky, Muraven & Tice, 1998; Baumeister, 2002), or of a progressive

139   reduction in the motivation required to continue expending effort on the same

140   task (Inzlicht & Schmeichel, 2012; Inzlicht, Schmeichel & Macrae, 2014;

141   Kurzban, Duckworth, Kable & Myers, 2013). Recent registered replication

142   reports (i.e. collections of independently conducted direct replications which

143   follow an identical protocol) find no evidence of the former, self-control

144   specific, ego-depletion effect (Hagger, Chatzisarantis, Alberts, Anggono,

145   Batailler et al, 2016), but, as outlined above, many observational studies

146   demonstrate predictable changes in behaviour and decision-making over time

147   that are compatible with the motivational account (Danziger et al, 2011;

148   Sievertsen et al, 2016; Dai et al, 2015). Within the context of nursing,

149   research which directly contrasts these opposing accounts of fatigue finds

150   motivational factors (perceived reward, perceived control) but not indicators of

151   remaining resource (energy expenditure, work demands) to be consistently

152   related to subjectively experienced fatigue over the working day (Johnston,

153   Allan, Powell, Jones, Farquharson et al, 2018). However, this work looks only

154   at the subjective fatigue reported by nurses and not at any potentially clinically

155   relevant consequences of that fatigue.

156   Both resource and motivational models would predict that decision

157   fatigue should arise as a result of progressive increases in uninterrupted 'time

on task' and consequently, that fatigue effects would be apparent in situations

where consecutive decisions are made without a break. Large numbers of

consecutive decisions are made in frontline healthcare services where health

professionals must make appropriate diagnostic and treatment decisions

about a series of patients in turn. Consequently, any systematic changes in

decision processes within this context would have clear implications for

service provision (Pignatiello, Martin & Hickman Jr, 2018). Furthermore, as

the most important predictors of patient outcomes in any clinical context are

likely to be fixed (e.g. severity of health condition), identifying new and

potentially modifiable theoretical determinants of these outcomes is important.

The present paper investigates the presence and extent of decision

fatigue effects in the healthcare context, specifically testing whether the

number of decisions made by health professionals since a break is, as

predicted by theory, associated with a predictable shift towards more

conservative (and therefore more expensive and less efficient) decisions. The

study focuses on nurses working for the NHS 24 telephone helpline, an NHS

Scotland wide service in which nurses assess callers' reported symptoms,

make decisions about the most appropriate course of action to take, and

direct callers onto primary or secondary care services where required. NHS

24 nurses deal with large numbers of cases and make many decisions each

day. Importantly for the current research, unlike the judges in Danziger et al's

study, nurses in the present study had no control over, or advance knowledge

of, the content of incoming calls and limited control over the timing of their

breaks, enabling a more robust test of the decision fatigue hypothesis. Using

data from ~4,000 real clinical decisions made by 150 nurses, the likelihood of

183   different decisions occurring is modelled from the beginning of a shift, up to

184   and following breaks during each shift. In line with theoretical accounts of

185   decision fatigue, it is expected that nurses will become increasingly likely to

186   make 'safer' and 'easier' (i.e. more conservative) treatment and management

187   decisions the more decisions they have made since their last break.

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189   The present study tests two hypotheses. The **decision fatigue hypothesis**

190   predicts that nurses will become increasingly likely to make conservative

191   decisions the more uninterrupted time they have spent 'on task' within each

192   work shift. If this hypothesis is correct, nurses should make increasingly

193   conservative decisions the more consecutive decisions they have made

194   and/or the more time that has passed *since their last break* (or in the case of

195   the period prior to the first break of day, since they started their shift). A critical

196   prediction of this hypothesis is that any shift in decision making will occur as a

197   function of time/decisions since last break rather than time elapsed/decisions

198   made in total over the working day as breaks represent the theorised

199   opportunity to replenish motivational and/or cognitive resources. To confirm

200   that any effect detected relates specifically to time/decisions *since break*, a

201   second hypothesis -the **general work hypothesis** -is also tested to determine

202   whether decision making changes predictably over the working day as whole

203   irrespective of opportunities to replenish motivational and/or cognitive

204   resources (i.e. breaks). If this general hypothesis is correct, nurses should

205   become increasingly likely to make conservative decisions the more

206   consecutive decisions they have made and/or the more time that has passed

207 in total *since the start of their shift* (regardless of breaks or time spent 'off-

208 task').

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210 Each hypothesis is tested in our models with both number of decisions and

211 time elapsed as predictors. This results in four planned analyses. Specifically,

212 the likelihood that nurses would direct callers to another health professional

213 within 12 hours (the most conservative decision) is modelled in relation to (1)

214 the number of consecutive decisions made/calls taken since the last break (or

215 start of shift if prior to first break), (2) time since last break (or start of shift if

216 prior to first break), (3) decisions made/calls taken in total since the start of

217 shift regardless of breaks, and (4) total time spent at work since the start of

218 shift regardless of breaks.

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220

221 **METHODS**

222

223 **Design and setting**

224

225 In a within-person, repeated measures study, data were collected on the

226 timing and number of calls and decisions made by nurses assessing callers to

227 the NHS 24 telephone service. NHS 24 is a nurse-led telephone (and now

228 online) advice service operating across Scotland and designed to provide >5

229 million members of the public with 24 hour access, 365 days a year, to health

230 services and information. Data for the present study were collected during a

231 comprehensive evaluation of the possible determinants and consequences of

232   stress in nurses working for the NHS 24 service between 2008 and 2010. The

233   original parent study included physiological, behavioural and cognitive

234   measures collected in real time over two full working shifts in addition to

235   information about the calls received by nurses during the measurement

236   period. The study protocol (Allan, Farquharson, Choudhary, Johnston, Jones

237   & Johnston, 2009) gives full details of these measures. Only methodological

238   information of relevance to the present study is presented here. The study

239   was reviewed and ethically approved by the NHS North of Scotland Research

240   Ethics Committee (05/S0801/136).

241

242   **Participants and recruitment**

243   All 465 nurses working in the four main NHS 24 call centres nationally or in

244   any of the 11 associated integrated local call centres were contacted with

245   study information and invited to take part in the study. Those interested in

246   participating (n=171 / 37% of the national workforce) returned a signed

247   consent form and arranged suitable shifts for participation. Four participants

248   were excluded (as they were taking medication that would interfere with heart

249   rate recordings taken in the main study), two participants withdrew, it was not

250   possible to schedule data collection with thirteen further participants and data

251   was not available for an additional two participants. This resulted in a final

252   sample of 150 participants (M age = 44 years, SD = 7.5). Most participants

253   were female (n = 142, representative of the gender split in this workforce) and

254   were employed in seven different call centres across Scotland. Participants

255   worked an average of 22.6 hours per week (SD = 10.4), had been qualified for

256   an average of 21 years (SD = 8.3) and had been employed by NHS 24 for an

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257   average of 3.5 years ($SD = 2.6$).

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259   **Procedure**

260   Participating nurses were asked to identify two 'typical' shifts from their next

261   month's rota where they would be available for participation and where they

262   would not be engaging in any non-standard activities (e.g. training, away days

263   etc). Data were collected on all calls received by each of the 150 participating

264   nurses over these two full working shifts. Call timing (time of day at which call

265   was taken) and duration (length of call in minutes/seconds) were

266   automatically recorded, and call outcomes (ambulance call-out, GP referral,

267   self-care, information provided, etc. see Table 1) were recorded by the nurse.

268   Most calls to the service are incoming (i.e. a standard call received from a

269   member of the public who has dialled the service or been routed from their

270   GPs number). However, during times of peak demand, urgent calls are

271   prioritised and less urgent calls are queued and returned by nurses later,

272   resulting in outgoing calls. Outgoing calls were excluded from the present

273   analysis as in these cases, nurses know in advance that the call is likely to be

274   non-urgent. Decision making within the service is supported by computerized

275   decision algorithms which highlight additional questions that nurses may wish

276   to ask /conditions that should be considered in response to particular

277   symptoms but in each case, the final decision on treatment / management is

278   made by an individual nurse.

279

280   **Data Coding**

281   Call outcomes - decisions taken by the nurse on which service the patient is

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282 referred to and with what level of urgency - were classified as either

283 conservative (i.e. clinically safest and cognitively easier decisions) or not. All

284 decisions where the patient was advised to urgently seek, or was directly

285 referred to primary or secondary care within 12 hours via an urgent as

286 opposed to routine pathway were conceptualized as the conservative option:

287 in these cases, callers would be assessed by at least two health professionals

288 (the NHS 24 nurse and a primary/secondary care practitioner/first responder)

289 within the same day. As patients in these cases are retained within the

290 healthcare system and are assessed via phone and then again face to face

291 the same day, this was deemed the safest option clinically. Such decisions

292 are also cognitively 'easier' as nurses do not need to offer detailed information

293 or instructions to the patient, can resolve any uncertainty they feel about the

294 best course of action and can handover final responsibility for treatment and

295 management decisions to another health professional. These calls were

296 compared to all other calls where outcomes reflected less conservative

297 courses of action (where callers were not retained continuously in the

298 healthcare system but were advised to seek primary or secondary care 'within

299 36 hours', or 'at their leisure').

300

301 Breaks from work were classified as any continuous period of 15 minutes or

302 more between consecutive calls as this reflects the minimum standard break

303 length within the NHS 24 service. Outside of official breaks, nurses are

304 required to remain at their stations so that they are 'available for call' and

305 consequently during these times are unlikely to be truly 'off-task'. The position

306 of each call within the sequence of calls received since (i) start of shift; and (ii)

307 the last break was computed as the predictor of interest.

308

309 **Analysis**

310 The final dataset had a two-level structure with triage decisions made during

311 incoming calls to the service (level-1; $k = 3{,}948$) nested within individual

312 nurses (level-2; $n = 150$). Nurses' decision making (1 = conservative; 0 = less

313 conservative; as defined above) exhibited meaningful and significant

314 clustering within nurses (ICC = 0.079, SE = 0.017, p< .001) and were

315 therefore analysed using two-level mixed-effects logistic regression models.

316 All models included a random intercept, and a fixed effect of shift (first of the

317 two participation shifts = 0; second shift = 1). Since calls at certain times of

318 day may be more likely to involve serious conditions (warranting more urgent

319 responses), all analyses also included time of day (entered as a series of hour

320 of day dummy variables). As participating nurses worked in either one of the

321 larger, main call centres (n=3) or in a smaller, regional call centre (n=4), call

322 centre size was also controlled for in analyses.

323

324 To test hypothesis 1 (the decision fatigue hypothesis) two models were

325 estimated with the following fixed effects added: Model (i) number of decisions

326 i.e. calls since last break; and Model (ii) time elapsed in hours since the last

327 break. To test hypothesis 2 (the general work hypothesis) a further two

328 models were estimated, with the following fixed effects added: Model (iii)

329 number of decisions since the start of the shift; and Model (iv) time elapsed in

330 hours since the start of the shift. All analyses were carried out in Stata 15.

331 Statistical significance was set at α = .05, corrected for multiple comparisons

332   (Bonferroni corrected α = .0125).

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334

335   **RESULTS**

336   The participating nurses did not significantly differ from the rest of the NHS 24

337   workforce in terms of years qualified ($t_{(373)}$ =-0.817, p=0.41), years of

338   employment ($t_{(271)}$ =-0.005, p=0.99), or number of hours worked per week (t

339     $_{(430)}$ =1.14, p=0.25).

340   During data collection, participating nurses dealt with 5,325 calls in

341   total (mean number of calls per nurse = 35.51; SD = 11.72). Of these, 95 calls

342   (1.8%) were coded as 'refused triage' meaning that either the call was

343   disconnected before a decision was made, or no decision could be agreed

344   between nurse and patient. As no decision was made during these 'refused

345   triage' calls, decisions in these cases were recorded as missing and were not

346   included in the analyses. A further 1,282 calls (24.1%) were outgoing calls

347   and were also excluded from the analyses as nurses in these cases had

348   advance knowledge that the call content was non-urgent. The remaining

349   3,948 calls were standard incoming calls and were included in the analyses.

350   During these incoming calls, 3,075 (77.9%) of the decisions made were

351   classified as conservative and 873 (22.1%) as not (see Table 1 for a

352   breakdown of call outcomes).

353   Participating nurses' shifts were on average 7.09 hours long (SD 1.73)

354   and involved an average of 13.78 incoming calls (SD= 6.82) each lasting an

355   average of 15.04 mins (SD = 6.08). There were 662 observed breaks lasting ≥

356   15 mins (mean = 2.30 breaks per shift; SD = 1.47. Median break length was

14

357 25 minutes (IQR 19-35). The average time from the end of a break (or from

358 the start of shift) to the end of the last call taken prior to the next break (or end

359 of shift) was 2.14 hours (SD=1.12). Nurses took an average of 4.35 incoming

360 calls (SD=3.61) between breaks.

361

362 [Table 1 here]

363

364 Table 2 presents the fixed effect regression coefficients from all four models

365 where each model controls for time of day, shift (first or second), and size of

366 call centre.

367

368 Model i (decisions since break) and ii (time since break) test the **decision**

369 **fatigue hypothesis**: whether nurses make more conservative decisions the

370 more consecutive decisions they have made and/or the more time that has

371 passed *since their last break*. The Model i results show that for every

372 additional call taken since their last break, the odds of nurses making a

373 conservative decision increased by 5.5% (p = .001, 95% CI: 2.2%, 8.8%). The

374 results for Model ii show a similar effect with time elapsed. The odds of

375 nurses making a conservative decision increase by 20.5% for every hour that

376 passes since the last break (p < .001, 95% CI: 9.1%, 33.2%). This translates

377 to an increase in odds of 49.0% from the first call after one break to the final

378 call taken before the next break (i.e. an average of 2.14 hours later).

379

380 Models iii (decisions since start of shift) and iv (time since start of shift), test

381 the **general work hypothesis**: whether nurses simply become more likely to

15

382 make more conservative decisions with more effort exerted during the whole

383 shift. These models found no effect on decision making of number of calls

384 (decisions) since the start of their shift (p = .529) nor time elapsed since start

385 of shift (p = .766).

386

387 [Table 2 here]

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389

390

391 **DISCUSSION**

392

393 The present analysis of ~4,000 clinical decisions made by nurses working for

394 the telephone based NHS 24 service, revealed evidence of a predictable,

395 mental-fatigue related bias in clinical decision making. Specifically, nurses

396 made progressively more conservative and therefore more expensive and

397 less efficient decisions as the time and the number of decisions made since

398 their last rest break increased. For every call taken since last break, the odds

399 of nurses recommending a treatment option that involved callers seeing

400 another primary or secondary care professional within 12 hours increased by

401 5.5%: an increase in odds, on average, of 20.5% an hour or 49.0% from just

402 after one break to just before the next. To convert this into relative

403 probabilities: relative to the first person to call in after a nurse's break, the

404 second caller will be 1.3% more likely to be retained within the healthcare

405 system and seen the same day by another health professional, but the final

406 caller before the next break will be 8.8% more likely to be seen the same day

407   (i.e. a modelled probability of 75.4% immediately after a break, increasing to

408   82.0% before the next break). This effect appears to be related specifically to

409   the number of decisions made / time that has elapsed *since a nurse's last*

410   *break* and not to an accumulation of general fatigue as decisions were

411   unaffected by the total number of calls taken or time at work over the shift as

412   a whole.

413

414   **Theoretical and clinical implications**

415   These results demonstrate that clinical decision makers are not immune to the

416   cognitive biases demonstrated in a range of other settings including law,

417   education and marketing (e.g. Danziger et al, 2011; Sievertsen et al, 2016;

418   Levav et al, 2010). Decision fatigue, i.e. the tendency to become increasingly

419   likely to go for the 'safe', 'default', or 'easy' option as the number of decisions

420   made increases, has long been exploited in the commercial sector. Economic

421   studies, for example, explicitly recommend that high mark-up options be

422   offered to customers late in a series of decisions to increase the likelihood of

423   them being accepted (Levav et al, 2010).

424   From a theoretical standpoint, the present findings cannot determine

425   whether the observed effects arise as the result of depletion of some general

426   cognitive resource or from a progressive shift in motivation away from current

427   task, but either way, they demonstrate that the effect is tied to the length of

428   continuous episodes of work (i.e. without a break) within a work period rather

429   than to the total or cumulative amount of work over the whole work period.

430   Within the clinical context, decision fatigue serves to bias decision

431   making in a conservative direction. This is optimal from a patient safety point

432   of view as retaining patients within the healthcare system will maximize the

433   chances that any detectable health conditions are recognised and treated

434   quickly. However, an increased tendency to refer patients to primary or

435   secondary care services within a short time frame may also increase the

436   number of unnecessary investigations carried out, increase patient anxiety,

437   skew patient expectations of care, and make less efficient use of limited

438   resources. Referring large numbers of patients to primary and secondary care

439   undermines one of the core aims of medical telephone helplines. NHS 24 was

440   established by the Scottish Government in 2001 with a vision to "…..reduce

441   the ever increasing burden on existing services" (NHS 24, 2004). Our analysis

442   suggests that health professionals may become increasingly unable to fulfill

443   this vision as time since break increases. Furthermore, it implies that at times

444   when services are under the highest levels of demand, decision making may

445   be least efficient, since at these times, staff may be less likely to take the

446   breaks required to combat decision fatigue.

447   Importantly, our analysis suggests that it would not be necessary to

448   reduce total workload or shift length in order to reduce the effects of decision

449   fatigue in health professionals. Rather, it suggests that strategic scheduling of

450   (frequent, short) breaks would be the best way to ensure that decision making

451   remains efficient throughout shifts. This may be particularly relevant for those

452   who consciously recognise cognitive changes occurring as previous analyses

453   from the same dataset (Allan, Farquharson, Johnston, Jones, Choudhary &

454   Johnston, 2014) indicate that nurses who report noticing that they are making

455   frequent cognitive failures (slips of attention and memory) are more likely in

456   general to refer callers on to other services.

457   Much empirical data suggests that breaks from work are restorative, in

458   that they function to reduce, or even reverse, fatigue-related changes in

459   decision making and performance. A study of job performance over four

460   weeks (Binnewies, Sonnetag & Mojza, 2010) found that when people had a

461   chance to fully recover from work demands during the weekend they reported

462   better performance of their core work tasks, were more likely to be proactive

463   and show initiative, and more likely to help others on their return to work.

464   Similarly, Dai et al (2015) demonstrated that while health professionals'

465   compliance with hand hygiene guidelines declined systematically over the

466   course of a 12-hour shift, workers with longer breaks between shifts showed

467   reduced depletion effects. While these studies look at 'breaks' in terms of

468   days off work, recent studies suggest that breaks in the day of 20-30 minutes

469   may be sufficient to completely remove cognitive depletion effects

470   (Sievertsen et al 2016). Similarly, there is some evidence to suggest that even

471   breaks of very short durations (3 minutes) are sufficient to mitigate depletion-

472   related declines in productivity (Dababneh, Swanson & Shell, 2001).

473

474   **Future Directions**

475   Future research may be usefully focused on identifying optimal patterns of

476   breaks within the working shifts of healthcare professionals. Nursing shifts are

477   typically longer (8-12 hours) than in other professions (Stimpfel, Sloane &

478   Aiken, 2012) and it is possible that multiple short breaks spaced across the

479   working shift (in addition to core meal and rest breaks) would improve rather

480   than reduce service efficiency. Sievertsen et al (2016) conclude in their study

481   of cognitive test performance over the day that the beneficial effect that

482   resulted from a 20-30 minute break was larger than the initial depletion effect,

483   indicating that frequent breaks over the day may actually improve overall

484   performance. Future studies could investigate varying lengths of break,

485   possibly using an experimental design. Clearly, in a demanding and often

486   short staffed NHS setting, the logistical reality of providing staff with frequent

487   breaks is extremely challenging, but the present analysis suggests this is

488   worth exploring. It is estimated that primary care appointments cost the NHS

489   an average of £120 each (NHS Information Services Division, 2012) so it is

490   possible that frequent, short breaks, if they can safely reduce the number of

491   patients being referred onto other services, could be cost effective.

492   For further development of theory, it is important to investigate whether

493   decision fatigue effects are indeed the result of progressive shifts in

494   motivation away from the current task. If so, then strategic incentives or

495   scheduled changes between different tasks may mitigate the effects.

496   Finally, the present study focused on telephone based nurses who are

497   largely sedentary during working hours. Future studies should investigate

498   whether decision fatigue is enhanced or ameliorated in physically active,

499   ward-based nurses, that is, whether physical and mental fatigue effects

500   interact.

501

502   **Strengths and weaknesses**

503   The present study utilises existing data on the timing and outcome of ~4,000

504   real clinical decisions and the analytical approach allows important theoretical

505   predictions about changes in this clinical decision making to be tested within

506   people over time. As the data replicate the decision fatigue phenomenon

507   observed in other professional groups (judges, GPs), it is likely that the results

508   are generalizable to other occupational settings. In terms of limitations, the

509   present study is observational in nature: it was not possible to experimentally

510   manipulate the timing and frequency of breaks. In addition, as data on call

511   content was not available, it was not possible to determine whether the

512   observed shift towards more conservative decisions was clinically less

513   'appropriate'. While similar studies indicate that clinicians' decision making

514   does become less appropriate over time (Linder et al, 2014), this could not be

515   tested directly in the present study. Finally, breaks were identified as any

516   period of >15 minutes between calls. While all such periods reflect a break

517   from active work, this method of classification is likely to include both officially

518   designated breaks where nurses are completely 'off-task' and periods of

519   inactivity at the workstation while still 'available for call'. The opportunities to

520   rest and recuperate from work may be reduced in the latter case and

521   consequently, the reported results may underestimate the magnitude of any

522   effect of breaks on decision making.

523

524   In conclusion, every consecutive decision that occurs, or hour that passes

525   since a break, produces a predictable and measurable change in nurses'

526   decision making that may function to gradually reduce service efficiency over

527   the working day. Future research should focus on identifying an optimal

528   pattern of breaks to minimize these effects.

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640 *Table 1. Descriptive data on calls*
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642

Decision taken by nurse	Frequency (n)
Referral within 12 hours (conservative) - Total	3075
Ambulance sent	390
Urgently attend accident & emergency	277
Urgently attend GP surgery	2382
Urgently speak to GP	17
Other[a]	9
Referral outside 12 hour window (less conservative)- Total	873
Attend GP surgery	320
Speak to GP	3
Information provided	176
Self-care advised	237
Other[b]	137
Refused Triage	95
Total calls handled	4043

643 [a] Other conservative referrals included to pharmacist, dentist, midwife, primary care
644 emergency centre
645 [b] Other less conservative referrals included to pharmacist, dentist, midwife, health visitor,
646 public health nurse, police, optician, breathing space (mental health) or poison information
647 service.
648
649

Table 2. Mixed effects logistic regressions predicting likelihood of nurses making conservative decisions from (i) number of decisions (calls) since last break, (ii) hours since last break, (iii) number of decisions (calls) since start of shift and (iv) hours since start of shift. Time was entered as a series of dummy hour of day variables and is included in all analyses shown. Complete tables (showing time variables in full) can be found in Supplementary Table S1.

	Odds Ratio	S.E	*p*	95% CI	
				Lower	Upper
Model i					
Decisions Since Break					
Intercept	3.135	0.649	< .001	2.089	4.703
Shift[a]	0.938	0.076	.430	0.801	1.090
Center Type[b]	1.891	0.353	.001	1.311	2.728
Decisions (calls) since break[c]	1.055	0.017	.001	1.022	1.088
McKelvey & Zavoina Pseudo R^2	0.065				
Model ii					
Time Since Break					
Intercept	3.067	0.635	< .001	2.044	4.603
Shift[a]	0.938	0.0766	.425	0.800	1.098
Center Type	1.825	0.344	<.001	1.289	2.668
Time (hrs) since break[c]	1.205	0.061	<.001	1.091	1.332
McKelvey & Zavoina Pseudo R^2	0.066				
Model iii					
Decisions Since Starting					
Intercept	3.410	0.739	< .001	2.230	5.215
Shift[a]	0.933	0.753	.390	0.796	1.093
Center Type	1.836	0.344	.001	1.272	2.651

Decisions (calls) since start of shift	1.006	0.009	.529	0.988	1.023
McKelvey & Zavoina Pseudo R^2	0.060				

Model iv

Time Since Starting

Intercept	3.685	0.841	< .001	2.356	5.765
Shift[a]	0.936	0.076	.412	0.799	1.097
Center Type	1.830	0.343	<.001	1.267	2.643
Time (hrs) since start of shift	0.992	0.026	.766	0.942	1.045
McKelvey & Zavoina Pseudo R^2	0.060				

[a] Shift coded as 0 = shift one, 1 = shift two; [b] center type coded as 0 = three large centers, 1 = four small centers; [c] Since last break, or start of shift if in first call period.