

Workflow interruptions, cognitive failure and near-accidents in health care

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Errors are frequent in health care. A specific model was tested that affirms failure in cognitive action regulation to mediate the influence of nurses' workflow interruptions and safety conscientiousness on near-accidents in health care. One hundred and sixty-five nurses from seven Swiss hospitals participated in a questionnaire survey. Structural equation modelling confirmed the hypothesised mediation model. Cognitive failure in action regulation significantly mediated the influence of workflow interruptions on near-accidents ($p < .05$). An indirect path from conscientiousness to near-accidents via cognitive failure in action regulation was also significant ($p < .05$). Compliance with safety regulations was significantly related to cognitive failure and near-accidents; moreover, cognitive failure mediated the association between compliance and near-accidents ($p < .05$). Contrary to expectations, compliance with safety regulations was not related to workflow interruptions. Workflow interruptions caused by colleagues, patients and organisational constraints are likely to trigger errors in nursing. Work redesign is recommended to reduce cognitive failure and improve safety of nurses and patients.

Keywords: occupational stress; nursing; patient safety; cognitive failure

Introduction

Workflow interruptions are common in health care (Weigl, Muller, Zupanc, Glaser, & Angerer, 2011) and are not bad per se (Grundgeiger & Sanderson, 2009). Often, there is a need to switch from one task to another more "urgent" task (Semmer, Grebner, & Elfering, 2010). Indeed, in emergency situations interruptions are often beneficial, however, in many other situations – like being asked for a room number while dispensing drug – they are not (Rivera-Rodriguez & Karsh, 2010).

Workflow interruptions and medical error

Workflow interruptions are linked to medical error (Institute of Medicine, 2000). Nevertheless, comparably few studies have examined interruption along with error in health care (7 out of 33 studies in a recent review of Rivera-Rodriguez & Karsh, 2010).

Workflow interruptions as a hindrance stressor

Time pressure may indicate that time shortness can be overcome by increasing work effort while workflow interruptions often imply that success is unlikely (Webster, Beehr,

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& Love, 2011). Thus, a challenging motivation may arise from time pressure (challenge stressors) while work interruptions (hindrance stressors) are not motivating but have negative effects on job performance (LePine, Podsakoff, & LePine, 2005) and safety compliance (Clarke, 2012). The meta-analysis by Clarke (2012) showed that hindrance stressors, including workflow interruptions, are positively related to occupational injuries and near-accidents while challenge stressors were not related to injuries.

Cognitive failure, conscientiousness and safety compliance

Error in action execution occurs in routine tasks that have been done without error many times (Broadbent, Cooper, Fitzgerald, & Parkes, 1982; Klumb, 1995), thus a mostly avoidable threat is placed on patient safety (Dieckmann, Reddersen, Wehner, & Rall, 2006). Not only interruptions at work but also safety compliance and conscientiousness may relate to error. Indeed, initial conceptualisations viewed error in routine tasks primarily as based on individual trait-like cognitive failure proneness (Reason, 1988, 1990). Safety compliance and conscientiousness should relate to more awareness in action regulation at the task at hand. Thus, we hypothesised that cognitive failure in action regulation mediates the associations between safety compliance and conscientiousness with near-accidents. Taken together, cognitive failure in action regulation was expected to be the proximal antecedent of near-accidents during nursing (Figure 1) linking workflow interruptions and near-accidents (H1), linking safety compliance and near-accidents (H2) and linking conscientiousness and near-accidents (H3).

Methods

Participants

All seven hospitals from a private hospital corporation in Switzerland agreed to participate in the study. The study design and its purpose were presented to nursing directors. All agreed to distribute the questionnaires, with post-paid envelopes, to their acute care units. Two hundred and ninety nurses were surveyed and after two weeks, nursing directors sent a written reminder. The response rate was 58% with 168 questionnaires returned. Three participants were excluded because they did no nursing work. The final

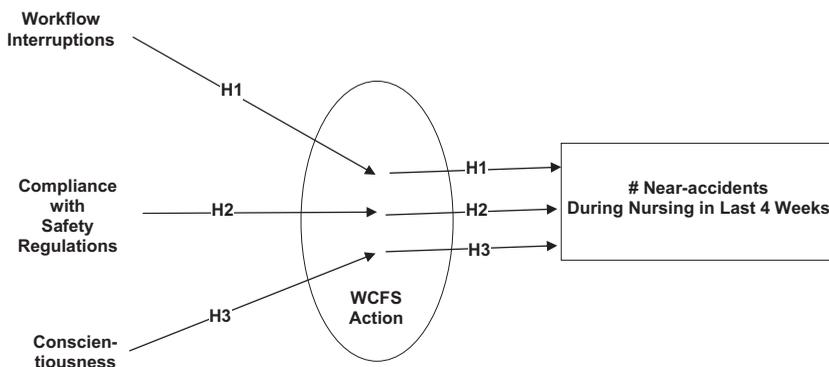


Figure 1. Hypotheses of work-related cognitive failure in action regulation (WCFS Action) as mediator of the effects of interruptions, safety compliance and conscientiousness on near-accidents.

sample included 14 male nurses and 151 female nurses. The mean age was 37.3 years (SD = 11.0 years). Mean job tenure was 13.4 years (SD = 11.0 years) and nurses worked, on average, 6.5 years in their current position (SD = 6.8 years). On average, nurses were in charge of 5.3 patients (SD = 2.2 patients). All participants gave their informed consent before questionnaires were distributed. The study was approved by the Ethics Committee of Kanton Bern, Switzerland (KEK #Z001/13) and was carried out in accordance with the Declaration of Helsinki.

Measures

Interruptions in nursing work

The “Activity and work analysis in hospitals” – self-report version (TAA-KH-S) was used (Büssing & Glaser, 2002). Fifteen questions measured interruptions by persons, malfunctions and blockings, such as interruptions times because of lacking materials. The response format was 1 = “never”–5 = “very often”.

Conscientiousness

The scale consists of six bipolar items on a six-point scale, with each pole ranging from “very” (1 and 6) and “quite” (2 and 5) to “rather” (3 and 4) (Schallberger & Venetz, 1999).

Near-accidents during nursing in last four weeks

The annotation and question was adapted from Musahl and Bendig (2005): “The following question refers to near-accidents during nursing. Near-accidents characterise situations when you or the patient had a narrow escape from experiencing an accident”. The question was “How many near-accidents do you remember in the last four weeks?” with number as response format.

Compliance with safety regulations

The single questionnaire item with a comment asked about safe working behaviour (“I pay attention to safety at work [compliance with safety regulations, consideration of recommended means to procedures, etc.]”, with responses ranging from 1 = “seldom” to 5 = “always”, Elfering, Semmer, & Grebner, 2006).

Cognitive failure in action regulation

The failure in action execution subscale of the Workplace Cognitive Failure Scale (WCFS action) was used (Elfering, Grebner, & Dudan, 2011; Wallace & Chen, 2005). The scale comprised of five items (e.g. “Unintentionally press control switches on machines?”). The response format was 1 = “never” to 5 = “very often”. All questionnaires were paper-pencil.

Data analysis

Because there were no correlations of hospital with WCFS action and near-misses, we did not control for hospital in the analyses. AMOS 18.0 was used to test mediation hypotheses with a bootstrap test of indirect effects (Preacher & Hayes, 2008).

The hypothesised structural equation model was compared with the accident-prone person model assuming that conscientiousness induces stable individual differences in action regulation. Thus, the assumption in the accident-prone person model is that WCFS action induces workflow interruptions. Hence, interruptions might then mediate the effects of WCFS action in near-accidents. A non-significant mediation and significantly worse fit of data in the accident-prone person model than in the hypothesised mediation model would increase the plausibility of the latter. Because of the directional hypothesis, the 5% α level was one-tailed (Wonnacott & Wonnacott, 1984).

Results

One or more near-accidents during nursing in the last four weeks were reported by more than half of the nurses (Table 1). Correlations are shown in Table 2.

Test of indirect effects in structural equation analyses

The measurement model and the hypothesised mediation model represented the empirical data very well (Table 3) and were comparable in fit ($\Delta\chi^2[1] = .16, ns$). Significant direct paths were observed from work interruptions to WCFS action ($\beta = .25, p < .01$), from conscientiousness to WCFS action ($\beta = -.27, p < .01$), and from WCFS action to near-accidents ($\beta = .18, p < .05$, Figure 2). The test of indirect, that is, mediation effects resulted in a significant “interruptions \rightarrow WCFS action \rightarrow near-accident path” (H1, $\beta = .05$, CI 90 = .01 to .10) and a significant “safety compliance \rightarrow WCFS action \rightarrow near-accident path” (H2, $\beta = -.03$, CI 90 = $-.08$ to $-.001$). The test of the third indirect effect resulted in a significant “conscientiousness \rightarrow WCFS action \rightarrow near-accident path” (H3, $\beta = -.05$, CI 90 = $-.11$ to $-.01$). Noteworthy, the indirect effects did not depend on the type of interruptions (i.e. persons, malfunction or blockings). Separate models for each type of interruption revealed significant indirect effects, too (Table 3).

In the alternative accident-prone person model, the directional path from interruptions to near-accidents was not significant ($\beta = .11, ns$) and therefore the test of interruptions as a mediator of the link between WCFS action and near-accidents was obsolete.

Table 1. Descriptive statistics and internal consistencies (Cronbach's α) for all study variables.

	Items	Range	<i>M</i>	<i>SD</i>	Cronbach's α
(1) # Near-accidents during nursing in last four weeks	1	Count	1.02	1.52	n.a.
(2) Workflow Interruptions Total	15	1–5	2.66	0.53	.87
(3) Interruptions by other persons	6	1–5	3.39	0.69	.85
(4) Interruptions by malfunction	4	1–5	2.30	0.61	.81
(5) Interruptions by blockings	5	1–5	2.28	0.60	.80
(6) Cognitive failure in action regulation (WCFS: Action)	5	1–5	1.86	0.50	.77
(7) Compliance with safety regulations	1	1–5	4.01	0.82	n.a.
(8) Conscientiousness	6	1–6	4.93	0.63	.83
(9) Age	1	Count	37.26	10.98	n.a.
(10) Sex (151 f, 14 m)	1	1–2	n.a.	n.a.	n.a.

Note: n.a. = not applicable.

Table 2. Intercorrelations of all study variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) # Near-accidents during nursing in last four weeks									
(2) Workflow Interruptions	.14*								
(3) Interruptions by other persons	.07	.77***							
(4) Interruptions by malfunction	.11	.84***	.44***						
(5) Interruptions by blockings	.13	.88***	.48***	.72***					
(6) WCFS: Action	.20**	.20**	.14*	.21**	.19**				
(7) Compliance with safety regulations	-.15*	.10	.07	.14*	.06	-.17*			
(8) Conscientiousness	-.04	-.02	-.01	-.07	.01	-.26***	.17*		
(9) Age	-.13	-.14*	-.27**	.03	-.08	-.17*	.15*	-.01	
(10) Sex (151 f, 14 m)	.07	-.17*	-.17*	-.11	-.12	-.01	-.22*	-.02	-.02

Notes: $N = 165$.

* $p < .05$; ** $p < .01$; *** $p < .01$ one-tailed.

Discussion

Empirical data confirmed a cognitive error model that focused on the disruptive properties of workflow interruptions. Unexpectedly, interruptions were not related to safety compliance in nurses and indeed this result may be nurse-specific. Many nurses may often show safety compliance despite frequent interruption simply because patient safety is a more salient goal than the other goals connected with the task at hand. Nevertheless, safety compliance was negatively related to cognitive failure as supposed by Clarke (2012). If one considers cognitive failure in action execution as proximal safety behaviour, results of this study confirmed the meta-analytical finding that safety behaviours mediate the link between hindrance stressors and occupational injuries (Clarke, 2012).

Work design should specifically reduce unnecessary interruptions (Elfering & Grebner, 2008). For example, clear liability to incoming calls could prevent more than one nurse to be interrupted by the same call (Baethge & Rigotti, 2013). Most interruptions are irrelevant to the task and therefore mistimed (Kahneman, 1973). Therefore, work design should provide interruption-free periods of time for some interference-prone tasks (for example, during dispersion of medicaments). Furthermore, work redesign should promote error management by simplifying error detection and help to learn from near-errors (Hofmann & Frese, 2011). Noteworthy, nurses have expert knowledge concerning interruptions and should participate in health circles (Baethge & Rigotti, 2013).

Limitations

There are several limitations. First, the study is only cross-sectional and the indirect paths should preferably be tested longitudinally. Secondly, all assessments were done by questionnaires. Bias from common source variance is likely (Semmer, Grebner, & Elfering, 2004). Another weakness is that response rate was low and thus bias cannot

Table 3. Structural equation models fit to empirical data and key indirect paths tested.

	χ^2	df	χ^2/df	p	CFI	RMSEA	AIC	Interruptions ▼ WCFSAction ▼ # Near-accidents β (CI90)	Safety Compl. ▼ WCFSAction ▼ # Near-accidents β (CI90)	Conscient. ▼ WCFSAction ▼ # Near-accidents β (CI90)
(1) Independence model	551.56	55	10.03	.00	0	.24	573.56			
(2) Saturated model	0	0	0	-	1.00	-	132.00			
(3) Measurement model	33.84	36	0.94	.57	1.00	.00	115.84			
(4) Hypothesised mediation model	34.00	37	0.92	.61	1.00	.00	114.00	.05 (.003 to .10)	-.03 (-.08 to .001)	-.05 (-.11 to -.01)
Only interruptions by persons included	96.40	70	1.38	.02	.96	.05	166.40	.04 (.001 to .08)	-.03 (-.08 to .001)	-.06 (-.12 to -.01)
Only interruptions by malfunction included	33.63	37	0.91	.63	1.00	.00	91.63	.05 (.003 to .11)	-.03 (-.08 to .001)	-.05 (-.10 to -.002)
Only interruptions by blockings included	91.54	58	1.58	.00	.95	.06	157.54	.04 (.002 to .08)	-.03 (-.08 to .001)	-.05 (-.11 to -.01)
(5) Alternative accident-prone person model	33.87	37	0.92	.62	1.00	.00	91.87	WCFSAction -> Interrup -># Near-accidents: .03 (-.009 to .08)		

Notes: Maximum-likelihood estimation. The models are as follows: (1) Independence model = no associations between study variables were assumed; (2) Saturated model = assumes all variables were interrelated – estimates best possible fit of model variables and empirical data; (3) Measurement model = all latent variables were specified and assumed to be no-directionally interrelated; (4) Hypothesised mediation model = mediation model as shown in Figure 1; (5) Alternative accident-prone person model = trait model, conscientiousness predicts WCFS Action and compliance with safety regulations, and WCFS Action predicts interruptions that directly link to near-accidents. χ^2 = Chi-square value indicates the minimum discrepancy between empirical covariance structures and those implied by the model; df = Degrees of freedom; χ^2/df = Minimum discrepancy divided by its degrees of freedom, as an indicator of fit; p = probability of the discrepancy to differ from zero (should be non-significant in a good model); p = p-value of minimum discrepancy divided by its degrees of freedom, which should be non-significant; CFI = Comparative fit index; RMSEA = Root mean square error of approximation, a measure of fit that takes into account the population moments rather than sample moments; AIC = Aikake information criterion, which should be as low as possible. A non-significant χ^2 , and CFI higher than .90 in the mediation model reflect acceptable fit between the model and the data (Schermelellh-Engel, Moosbrugger, & Müller, 2003). RMSEA value below .05 reflects a good fit of the model (Schermelellh-Engel, Moosbrugger, & Müller, 2003). The comparably low Aikake information criterion attests to the parsimonious informative modelling in the hypothesised mediation model.

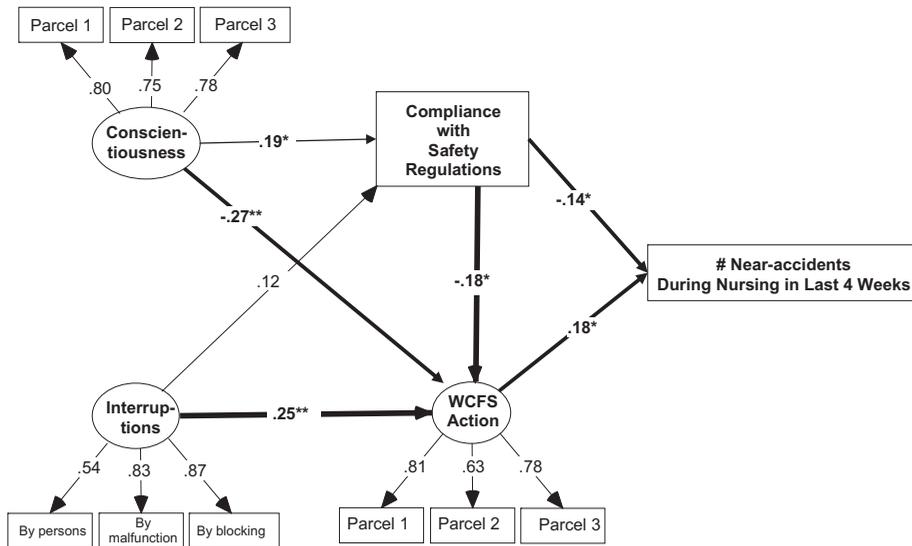


Figure 2. Model of work-related WCFS action (WCFS Action) as mediator of the effects of interruptions and conscientiousness on near-accidents.

be excluded. Finally, there was no differentiation between the near-accidents of patients and those that occurred to nurses. There is, however, good evidence that interruption is valid to predict both (Taylor et al., 2012).

Conclusion

The action regulation approach to workflow interruptions may help to improve safety for nurses and patients.

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