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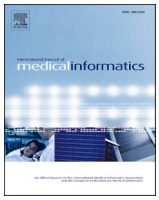

Change in nurses' psychosocial characteristics pre- and post-electronic medical record system implementation coinciding with the SARS-CoV-2 pandemic: pre- and post-cross-sectional surveys

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ABSTRACT

Background: The impacts of electronic medical record implementation on nurses, the largest healthcare workforce, have not been comprehensively examined. Negative impacts on nurses have implications for quality of patient care delivery and workforce retention.
Objective: To investigate changes in nurses' well-being, intention to stay, burnout, work engagement, satisfaction, motivation and experience using technology pre- and post-implementation of an organisation-wide electronic medical record in Victoria, Australia.
Methods: The natural experiment comprised an electronic medical record system implementation across six hospitals of a large tertiary healthcare organisation. Cross-sectional surveys were collected pre-electronic medical record implementation prior to the SARS-CoV-2 pandemic in 2019, and 18-months post-electronic medical record implementation during the pandemic in 2020, and findings compared.
Results: A total of 942 surveys were analysed (550 pre-electronic medical record (response rate 15.52%) and 392 post-electronic medical record (response rate 9.50%)). Post-electronic medical record, nurses' work satisfaction ($r = 0.23$, $p=<0.001$), intention to stay ($r = 0.11$, $p = 0.001$) and well-being ($r = 0.17$, $p=<0.001$) decreased. Nurses' perceived competence increased ($r = 0.10$, $p = 0.002$) despite decreased autonomy ($r = 0.10$, $p = 0.003$). Two of three dimensions of work engagement worsened (vigour $r = 0.13$, $p=<0.001$; dedication $r = 0.13$, $p=<0.001$) and all dimensions of burnout increased (exhaustion $r = 0.08$, $p = 0.012$, cynicism $r = 0.07$, $p = 0.04$ and reduced efficiency $r = 0.32$, $p=<0.001$). Nurses reported more burnout symptoms (95% CI 4.6–4.7%, $p = 0.036$), were less engaged (95% CI 49.6–49.9%, $p=<0.001$) and career trajectory satisfaction decreased ($r = 0.15$, $p=<0.001$). Matched data from 52 nurses showed changes in the same direction for all items except career trajectory satisfaction, hence validated findings from the larger unmatched sample.
Conclusions: Implementation of an electronic medical record immediately followed by the SARS-CoV-2 pandemic was associated with negative changes in nurses' well-being, intention to stay, burnout, work engagement and satisfaction.

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1. Introduction

Electronic medical record (EMR) systems have been implemented throughout hospitals worldwide, replacing paper-based clinical information and documentation systems. Negative impacts of EMR systems on medical professionals' well-being include burnout and have been well documented [1]. Nurses are the largest users of EMR systems in hospitals, yet, are under-represented in current research about how EMR systems influence health professionals' well-being. Examinations of the impact of EMR implementation on nurses have predominantly focused on measuring compliance, satisfaction or system usability [2]. Emerging evidence suggests nurses have negative experiences of EMR usability and insufficient time for EMR documentation, factors previously associated with high burden of burnout symptoms [3].

Nurses' well-being is positively associated with work satisfaction, productivity, and patient safety; and negatively associated with burnout [4]. Burnout develops from sustained physical and/or psychological stress and has detrimental effects on nurses' physical and psychological health and quality of patient care [5]. Burnout is costly to healthcare organizations due to associated low work satisfaction and work quality, and higher nurse turnover [6]. Nurses' work-related burnout can be mitigated by high levels of work engagement, autonomy, satisfaction and motivation [7].

Poor work satisfaction is an important factor in causing nurses leaving the workforce, and contributes to negative psychological, physical and financial consequences for nurses, patients, and healthcare organizations [8]. The impact of EMRs on nurses' well-being, intention to stay and work satisfaction and engagement in the workplace are largely unknown [9]. Gaps in understanding the relationships between nurses' motivation to use technology, engagement and satisfaction, burnout and well-being can hinder implementation, adoption and optimisation of EMR systems for nurses [10]. The multiple factors that may impact nurses, or be impacted by an EMR implementation, were operationalised using the study constructs of: well-being (encompassing psychosocial well-being and burnout); work engagement (encompassing work satisfaction, intention to stay, aspects of work engagement, team safety and career trajectory satisfaction); motivation to use technology (perceived competence and relative autonomy); and experiences of using EMR.

Problems with nurse workforce retention and productivity are a global challenge highlighted and exacerbated by the SARS-CoV-2 pandemic [11]. Australia had a proactive and preventative strategy in response to the pandemic. This strategy included lockdown measures, of which Melbourne, Victoria recorded the longest lockdown globally, where travel was not permitted, curfews were implemented, visitors to healthcare services were limited and retail trade was restricted to essential services [12].

1.1. Significance and aim

Introducing new technology into already complex healthcare systems affects nurses' work and workflows, well-being, interpersonal interactions and delivery of patient care [10]. Nurses' well-being, work engagement and motivation to use technology are all important for work productivity, retention and care quality, however, these factors have not previously been investigated in relation to EMR implementation. The aim of this study was to investigate change in nurses' well-being, intention to stay, burnout, work engagement, work satisfaction and motivation to use technology pre- and post-EMR system implementation. A secondary aim was to explore the relationships between these variables. This study provided insights into the impacts on nurses of implementing a new organisation-wide EMR system and the pandemic.

2. Material and methods

The natural experiment of an organisation-wide EMR implementation coincidentally occurred just prior to the pandemic in 2019–2020. As part of a larger program of research, cross-sectional surveys were used to collect data on nurses' well-being, work engagement and motivation to use technology both pre- and up to 18 months post-EMR implementation. In the absence of clear recommendations for the best timeframe for post-EMR implementation evaluation, data collection was planned initially for 12 months post-implementation, but was extended to 18 months post-implementation in response to the impacts of the SARS-CoV-2 pandemic on data collection in the clinical setting. The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) checklist was used for data reporting [13].

2.1. Setting, inclusion and exclusion criteria

The settings were six hospitals of a large tertiary healthcare organisation in Victoria, Australia providing inpatient care for adults, paediatrics and neonates. The EMR system implementation at the different hospitals was staggered across three time points between August-November 2019. Inclusion criteria included all nurses working in inpatient areas throughout the six hospitals where the EMR was implemented. Nurses working across multiple areas, on a casual basis, or for the EMR team were excluded.

Post-implementation data collection commenced after the healthcare organisation had experienced pandemic-related changes to nurses' work and workforce in preparation for SARS-CoV-2-positive patients. This included education and training for all nursing staff, including use of personal protective equipment and fit testing of masks. In January 2020, this Victorian healthcare organisation was the first in Australia to care for a patient hospitalised with SARS-CoV-2. Since then, constant pressure in response to the pandemic has been ongoing. Despite the pandemic, the healthcare organisation continued to have increased nursing workforce growth.

2.2. Recruitment and ethical approval

Online data collection occurred January-November 2019 (pre-EMR) and November 2020-June 2021 (post-EMR) via Qualtrics (Provo, Utah, USA). Invitations and two reminder e-mails with participant information, survey link and QR code to encourage survey completion, were sent to all eligible nurses via departmental nurse managers and education teams. Advertising used printed invitations with QR code and URL link for participants to access the anonymous survey. Executive support and university-hospital logos were used to enhance study credibility and promote responses. Participants were provided with instructions to create a unique code to enable matching of pre and post responses from the same individuals.

A minimum sample size of 270 surveys was required to provide a minimum of 10 responses per survey tool dimension (including planned sub-analysis) ($n = 27$) for planned analyses testing relationships between study constructs (well-being, work engagement, motivation to use technology and experience using EMR) and EMR implementation.[14] Submitting a completed survey indicated consent. Health service and University Human Research Ethics Committees approvals were obtained (reference numbers HREC/46439/MonH-2018–154603(v3) and 2019–003).

2.3. Survey design and statistical analyses

Valid, reliable and shortened versions of tools (to minimise participant burden) were used with permission to measure the study constructs (well-being, work engagement, motivation to use technology, and experience of using EMR). Tools were presented in the same order for both surveys. Three additional tools capturing nurses' experiences of EMR use were included in the post-EMR survey. Table 1 provides details of the survey tools used to examine the study constructs, their dimensions, number of items and response options. The pre-EMR survey

Table 1
Pre- and post-electronic medical record survey tools' characteristics.

Study construct	Dimensions	Pre- or post-measurement*	Survey tool	Number of questions	Response options
Well-being	Well-being	Pre and post	Well-Being Index[15]	5	5-point Likert scale (0 at no time – 4 Most of the time)
	Exhaustion, Cynicism, Reduced Efficiency	Pre and post	Maslach Burnout Inventory [16]	9	7-point Likert scale (0 Never – 6 Always)
Work engagement	Work satisfaction	Pre and post	Work Satisfaction[17]	1	Score out of 10 (1–10)
	Intention to stay (intention to leave and reverse-scored)	Pre and post	Intention to stay	1	Score out of 10 (1–10)
	Vigour, Dedication, Absorption	Pre and post	Utrecht Work Engagement Scale[18]	3	7-point Likert scale (0 Never – 6 Always)
	Team safety, Career trajectory satisfaction,	Pre and post	Psychological Safety questions[19] (adapted)	3 (2 team safety and 1 career trajectory satisfaction)	5-point Likert scale (1 Strongly Disagree – 5 Strongly agree)
Motivation to use technology	Perceived Competence, Relative Autonomy Index	Pre and post	Autonomy and Competence in Technology Adoption[20]	14	5-point Likert scale (1 Not all the time – 5 Very true)
Experience using electronic medical record	Competence, Autonomy, Relatedness	Post	Technology-based Experience of Need Satisfaction-Interface[20]	15	5-point Likert scale (1 Do not agree – 5 Strongly agree)
			Technology-based Experience of Need Satisfaction-Task[20]	12	5-point Likert scale (1 Do not agree – 5 Strongly agree)
			Technology-based Experience of Need Satisfaction-Life[20]	10	5-point Likert scale (1 Do not agree – 5 Strongly agree)
Participant demographics information	Age, Gender, Nurse classification, Years worked as a nurse, Highest level of education, Hours worked per fortnight, Work location, Site of the healthcare organisation	Pre and post	Demographics	8	Not applicable

* Pre- or post-EMR implementation.

was pre-tested for clarity with 12 nurses who did not meet eligibility criteria; no changes were required. Survey data were analysed using IBM SPSS Statistics (V27) for Windows. Tools were analysed and scored using author instructions. Where possible, the unique identifier was used to match individuals' pre- and post-EMR survey responses. Variables' frequencies and descriptive statistics, tests of normality, tool reliability, relationships between variables, and relationships between variables and nurse characteristics were examined. Participants' demographic information was compared between pre- and post-EMR groups, and partial correlations were run to account for potential sample differences in clinical work areas and healthcare organisation sites. Bonferroni corrections and adjustments (multiple tests) were applied to all significance values and tests were two-tailed. To assess normality, missing values were excluded pairwise; for other tests cases were excluded test-by-test. Cohen's criteria for effect sizes (r) was used [14].

3. Results

In total, 942 surveys were included in statistical analyses (550 pre-EMR and 392 post-EMR). Post-EMR, 406 survey responses were received (response rate 9.76%), of which 14 were removed from analysis (three incomplete responses and 11 from ineligible participants). Data from 52 nurses matched pre- and post-EMR using unique identifier codes were used for sub-group analysis.

Participants' demographic characteristics were similar pre- and post-EMR implementation; participants were mostly female, aged 20–39 years old, classified as a Registered Nurse, had 4.5–9 years nursing experience, a degree as their highest qualification and worked part-time (49–64 h per fortnight) (Table 2). Statistically significant differences were found between pre- and post-EMR participants' clinical work area and site of the healthcare organisation.

Three survey tools were not tested for reliability due to the small number of items for each tool.[21] All other survey tools had acceptable measures of reliability in both pre- and post-EMR samples (Cronbach's alpha levels > 0.7): Well-being Index = 0.874 (pre), 0.893 (post); Autonomy and Competence in Technology Adoption = 0.798 (pre), 0.831 (post); Technology-based Experience of Need Satisfaction-Interface = 0.905 (post); Technology-based Experience of Need Satisfaction-Task = 0.768 (post); Technology-based Experience of Need Satisfaction-Life = 0.845 (post); Utrecht Work Engagement Scale = 0.799 (pre), 0.785 (post); Maslach Burnout Inventory = 0.807 (pre), 0.809 (post). All survey tools had Kolmogorov-Smirnov significance levels of < 0.001 (for tests of normality). As data were not normally distributed, non-parametric tests were used for analysis [14].

Table 2
Participants' demographic characteristic pre- and post-electronic medical record.

Demographic variables		Pre-electronic medical record	Post-electronic medical record	Mean (SD)	Median (IQRs)	Range	Statistical Analysis
		n(%)					
Age (years)	20–29	167(30.4)	110(28.1)	Pre 37.89 (11.93) Post 39.36 (12.81)	Pre 35 (28–47) Post 36 (29–50)	Pre 21–69 Post 21–71	Mann-Whitney U Test Pre (Md = 35, n = 533) and post (Md = 36, n = 384), U = 108324.500, z = 1.514, p = 0.130, r = 0.050
	30–39	151(27.5)	113(28.8)				
	40–49	104(18.9)	60(15.3)				
	50–59	77(14.0)	69(17.6)				
	60–69	34(6.2)	29(17.6)				
	70–79	0(0)	3(0.8)				
	Missing	17(3.1)	8(2)				
Gender	Male	47(8.5)	32(8.2)				Chi-square test for independence $\chi^2(2, n = 936) = 0.055$, p = 0.973, Cramer's V = 0.008
	Female	491(89.3)	352(89.8)				
	Other/prefer not to say	8(1.5)	6(1.5)				
	Missing	4(0.7)	2(0.5)				
Nurse classification	Registered Nurse	57(10.4)	47(12)				Chi-square test for independence $\chi^2(7, n = 933) = 10.490$, p = 0.162, Cramer's V = 0.106
	(Graduate)	237(43.1)	155(39.5)				
	Registered Nurse (Grade	39(7.1)	25(6.4)				
	2)	90(16.4)	88(22.4)				
	Enrolled Nurse	79(14.4)	46(11.7)				
	Clinical Nurse Specialist	22(4.0)	14(3.6)				
	Associate Nurse Unit	13(2.4)	14(3.6)				
	Manager Nurse Manager	6(1.1)	1(0.3)				
	Educator	7(1.3)	2(0.5)				
	Nurse Consultant/ Practitioner						
	Missing						
Years worked as a nurse	0–4	130(23.6)	85(21.7)	Pre 13.96 (11.84) Post 15.05 (12.64)	Pre 10 (5–20) Post 10 (5–23)	Pre 0–54 Post 0–53	Mann-Whitney U Test Pre (Md = 10, n = 535) and post (Md = 10, n = 379), U = 105709.500, z = 1.101, p = 0.271, r = 0.036
	4.5–9	115(20.9)	86(21.9)				
	10–14	84(15.3)	57(14.5)				
	15–19	60(10.9)	26(6.6)				
	20–24	45(8.2)	35(8.9)				
	25–29	27(4.9)	22(5.6)				
	30–34	30(5.5)	27(6.9)				
	35–39	19(3.5)	17(4.3)				
	40–44	13(2.4)	17(4.3)				
	45–49	10(1.8)	3(0.8)				
	50–54	2(0.4)	4(1)				
	Missing	15(2.7)	13(3.3)				
Highest level of education	High school	11(2.0)	2(0.5)				Chi-square test for independence $\chi^2(4, n = 925) = 6.188$, p = 0.186, Cramer's V = 0.082
	Diploma or Certificate	51(9.3)	43(11)				
	Degree	234(42.5)	178(45.4)				
	Postgraduate Certificate or Diploma	186(33.8)	115(29.3)				
	Higher degree (Masters or PhD)	61(11.1)	44(11.2)				
	Missing	7(1.3)	10(2.6)				
Hours worked per fortnight (on average)	0–16	12(2.2)	6(1.5)	Pre 58.54 (18.11) Post 58.66 (17.65)	Pre 64 (48–72) Post 64 (48–70)	Pre 1–120 Post 7–92	Mann-Whitney U Test Pre (Md = 64, n = 533) and post (Md = 64,n = 380), U = 101976.00, z = 0.183, p = 0.855, r = 0.006
	17–32	60(10.9)	49(12.5)				
	33–48	95(17.3)	61(15.6)				
	49–64	210(38.2)	152(38.8)				
	65–80	139(25.3)	104(26.5)				
	>80	17(3.1)	8(2)				
	Missing	17(3.1)	12(3.1)				
Clinical work area	Medical/Surgical ward	155(28.2)	127(32.4)				Chi-square test for independence $\chi^2(4, n = 924) = 33.215$, p=<0.001**, Cramer's V = 0.190
	Critical Care	226(41.1)	160(40.8)				
	Paediatrics	77(14.0)	17(4.3)				
	Sub-acute	63(11.5)	39(9.9)				
	Procedural Units	23(4.2)	37(9.4)				
	Other (not specified)	2(0.4)	2(0.5)				
	Missing	4(0.7)	10(2.6)				
Site of the healthcare organisation	A	90(16.4)	58(14.8)				Chi-square test for independence $\chi^2(5, n = 927) = 33.465$, p=<0.001**, Cramer's V = 0.190
	B	49(8.9)	31(7.9)				
	C	102(18.5)	40(10.2)				
	D	142(25.8)	163(41.6)				
	E	53(9.6)	23(5.9)				
	F	105(19.4)	68(17.3)				
	Other (not specified)	1(0.2)	0(0)				
	Missing	5(0.9)	9(2.3)				

SD = Standard deviation. IQR = Interquartile Range (25%-75%). *p < 0.05. **p < 0.01. r = 0.1 = small effect size, 0.3 = medium effect size.

3.1. Change in measures

Statistically significant changes were detected post-EMR. No change was detected for one work engagement tool component (absorption), a question on psychological safety, and one burnout spectrum component (number of overextended nurses). Table 3 presents the pre- and post-EMR survey data.

Table 3
Pre- and post-survey results.

Study construct	Survey Tool (component)		Mean (SD)	95% Confidence Interval	Median(IQRs)	n	Mann-Whitney U	Z value	p-value	r
Well-being	Well-being Index %	Pre	61.29 (17.84)	59.80–62.78	64.00 (48.00–76.00)	550	86186.50	−5.265	<0.001**	0.17
		Post	54.65 (20.11)	52.66–56.64	56.00 (40.00–68.00)	392				
	Maslach Burnout Inventory (Exhaustion)	Pre	2.05 (1.16)	1.95–2.15	1.67 (1.33–2.67)	547	115713.50	2.515	0.012*	0.08
		Post	2.19 (1.13)	2.08–2.30	2(1.33–3.00)	386				
	Maslach Burnout Inventory (Cynicism)	Pre	1.47 (1.23)	1.37–1.57	1.33 (0.67–2.00)	547	113872.50	2.058	0.040*	0.07
		Post	1.57 (1.12)	1.46–1.68	1.33 (0.67–2.33)	386				
	Maslach Burnout Inventory (Reduced Efficiency)	Pre	1.74 (1.03)	1.65–1.83	1.67 (1.00–2.33)	547	145224.50	9.755	<0.001**	0.32
		Post	2.37 (0.87)	2.28–2.46	2.33 (1.67–3.00)	387				
Work engagement	Work satisfaction	Pre	7.81 (1.96)	7.65–7.97	8.00 (7.00–9.00)	546	79090.00	−6.938	<0.001**	0.23
		Post	6.99 (2.03)	6.79–7.19	7.00 (6.00–8.00)	392				
	Intention to stay	Pre	8.10 (2.60)	7.88–8.32	9.00 (7.00–10.00)	546	93811.50	−3.392	0.001**	0.11
		Post	7.53 (2.79)	7.25–7.81	9.00 (6.00–10.00)	392				
	Utrecht Work Engagement Scale (Vigour)	Pre	3.40 (1.06)	3.31–3.49	3.00 (3.00–4.00)	547	89539.50	−4.070	<0.001**	0.13
		Post	3.03 (1.30)	2.90–3.16	3.00 (2.00–4.00)	385				
	Utrecht Work Engagement Scale (Dedication)	Pre	4.30 (1.09)	4.21–4.39	4.00 (4.00–5.00)	547	90210.00	−3.297	<0.001**	0.13
		Post	3.98 (1.23)	3.86–4.10	4.00 (3.00–5.00)	386				
	Utrecht Work Engagement Scale (Absorption)	Pre	4.24 (1.09)	4.15–4.33	4.00 (4.00–5.00)	545	99689.00	−1.345	0.179	
		Post	4.12 (1.18)	4.00–4.24	4.00 (3.00–5.00)	385				
	Career Trajectory Satisfaction	Pre	3.65 (0.83)	3.58–3.72	4.00 (3.00–4.00)	546	87600.00	−4.590	<0.001**	0.15
		Post	3.34 (1.00)	3.24–3.44	4.00 (3.00–4.00)	384				
	Psychological Safety	Pre	2.91 (0.77)	2.85–2.97	3.00(2.5–3.5)	547	111815.50	1.786	0.074	
		Post	2.98 (0.84)	2.90–3.06	3.00(2.5–3.5)	383				
Motivation to use technology	Autonomy and Competence in Technology Adoption (Perceived competence)	Pre	3.36 (1.07)	3.27–3.45	3.50 (2.50–4.00)	544	118354.00	3.052	0.002*	0.10
		Post	3.57 (1.10)	3.46–3.68	3.50 (3.00–4.50)	390				
	Autonomy and Competence in Technology Adoption (Relative Autonomy Index)	Pre	0.02 (1.07)	−0.07–0.11	0.00 (-0.67–0.67)	544	93926.00	−2.993	0.003*	0.10
		Post	−0.23 (1.19)	−0.35- −0.11	−0.17 (-1.00–0.50)	390				
Experience using electronic medical record	Technology Effects on Need Satisfaction-Interface (Competence)	Post	3.22 (0.91)	3.13–3.31	3.20 (2.60–3.80)	390	N/A	N/A	N/A	N/A
	Technology Effects on Need Satisfaction-Interface (Autonomy)	Post	3.31 (0.96)	3.21–3.41	3.40 (2.60–4.00)	391	N/A	N/A	N/A	N/A
	Technology Effects on Need Satisfaction-Interface (Relatedness)	Post	2.66 (0.95)	2.57–2.75	2.60 (2.00–3.20)	390	N/A	N/A	N/A	N/A
	Technology Effects on Need Satisfaction-Task (Competence)	Post	3.64 (0.77)	3.56–3.72	3.75 (3.13–4.25)	389	N/A	N/A	N/A	N/A
	Technology Effects on Need Satisfaction-Task (Autonomy)	Post	3.47 (0.80)	3.39–3.55	3.50 (3.00–4.00)	389	N/A	N/A	N/A	N/A
	Technology Effects on Need Satisfaction-Task (Relatedness)	Post	3.55 (0.86)	3.46–3.64	3.50 (3.00–4.25)	390	N/A	N/A	N/A	N/A
	Technology Effects on Need Satisfaction-Life (Competence)	Post	3.92 (1.07)	3.81–4.03	4.00 (3.33–5.00)	387	N/A	N/A	N/A	N/A
	Technology Effects on Need Satisfaction-Life (Autonomy)	Post	3.30 (1.09)	3.19–3.41	3.50 (2.50–4.00)	388	N/A	N/A	N/A	N/A
	Technology Effects on Need Satisfaction-Life (Relatedness)	Post	2.10 (1.06)	1.99–2.21	2.00 (1.00–3.00)	389	N/A	N/A	N/A	N/A

N/A = Not applicable *$p < 0.05$. **$p < 0.01$. r = 0.1 = small effect size, 0.3 = medium effect size.

3.1.1. Well-being

Post-EMR, nurses' self-reported well-being decreased (pre median 64.00(IQR 48.00–76.00), post median 56.00(IQR 40.00–68.00), p=<0.001, r = 0.17), measured using the Well-being Index.[15] Table 4 presents the participants' results on the self-reported burnout spectrum, a sub-analysis of the MBI[22]: there was a decrease in proportion of nurses classified as engaged (pre 64.7%, post 49.7%, p=<0.001) and disengaged (pre 2.7%, post 2.1%, p = 0.036); an increase in nurses classified as ineffective (pre 9.9%, post 19.6%, p=<0.001), overextended (pre 10.2%, post 11.9%, p = 0.482) and burnout (pre 2%, post 4.7%, p = 0.036). The three Maslach Burnout Inventory[16] dimensions of exhaustion, cynicism and reduced efficiency increased, indicating a more stressed workforce (exhaustion pre median 1.67(IQR 1.33–2.67), post median 2.00(IQR 1.33–3), p = 0.012, r = 0.08; cynicism pre median 1.33(IQR 0.67–2), post median 1.33(IQR 0.67–2.33), p = 0.040, r = 0.07; reduced efficiency pre median 1.67(IQR 1–2.33), post median 2.33 (IQR 1.67–3), p=<0.001, r = 0.32).

3.1.2. Work engagement

Work satisfaction decreased post-EMR (pre mean 7.81(SD 1.96), post mean 6.99(SD 2.03), p=<0.001, r = 0.23). Nurses' intention to stay in their roles also reduced (pre mean 8.10(SD 2.60), post mean 7.53(SD 2.79), p = 0.001, r = 0.11). The Utrecht Work Engagement Scale[18] dimensions of vigour, dedication and absorption all decreased (vigour pre mean 3.40(SD 1.06), post mean 3.03(SD 1.30), p=<0.001, r = 0.13; dedication pre mean 4.30(SD 1.09), post mean 3.98(SD 1.23), p=<0.001, r = 0.13; absorption pre mean 4.24(SD 1.09), post mean 4.12 (SD 1.18), p = 0.179), as did nurses' responses on career trajectory satisfaction (pre mean 3.65(SD 0.83), post mean 3.34(SD 1.00), p=<0.001, r = 0.15). In contrast, nurses' perceived psychological safety at work increased (pre mean 2.91(SD 0.77), post mean 2.98(SD 0.84), p = 0.074).

3.1.3. Motivation to use technology

Nurses' perceived competence in EMR use increased post-implementation (pre mean 3.36(SD 1.07), post mean 3.57(SD 1.10), p = 0.002, r = 0.10), and perceived external drivers influenced EMR use (rather than internal drivers) (pre mean 0.02(SD 1.07), post mean −0.23 (SD 1.19), p = 0.003, r = 0.10), both measured using components of the Autonomy and Competence in Technology Adoption tool.[20].

3.1.4. Experience using EMR

Mean scores (out of five) for each dimension of competence, autonomy and relatedness were calculated for the three EMR experience tools: Technology Effects on Need Satisfaction-Interface (EMR satisfaction related to using EMR), Technology Effects on Need Satisfaction-Task (EMR satisfaction related to performing nursing tasks), and Technology Effects on Need Satisfaction-Life (EMR satisfaction related to their life more broadly).[20] Nurses' autonomy and relatedness to EMR was highest when related to nursing tasks (highest mean autonomy and relatedness scores 3.47(SD 0.80) and 3.55(SD 0.86) respectively), and competence was highest when thinking about how EMR may impact their life more broadly (highest mean competence score 3.92(SD 1.07)).

3.2. Relationships between variables

Positive relationships between variables, evident pre- and post-EMR, included: work satisfaction and intention to stay; work satisfaction and well-being; work satisfaction and relative autonomy; work satisfaction and engagement; intention to stay and well-being; intention to stay and engagement; well-being and relative autonomy; well-being and engagement; burnout and years worked; and burnout and age. Negative relationships between variables both pre- and post-EMR included: work satisfaction and burnout; work satisfaction and age; work satisfaction and years worked; intention to stay and burnout; well-being and burnout; relative autonomy and age; relative autonomy and years worked; and engagement and burnout. The positive relationship between intention to stay and relative autonomy, and negative relationship between engagement and hours worked were only evident post-EMR. Table 5 presents pre- and post-EMR correlations between study variables accounting for both work location and healthcare organisation site. Appendices A and B present pre-EMR correlations between study variables and post-EMR correlations between study variables respectively.

3.3. Relationships between variables and nurse characteristics

Nurses working at smaller hospital sites (sites B and E without emergency departments and critical care areas) had higher work satisfaction pre-EMR and higher well-being scores post-EMR (pre-EMR Site E higher median score than Site B, $\chi2 = 17.695$ (df = 6, N = 541), p = 0.031, r = 0.14; Site E higher median score than Site D, $\chi2 = 17.695$ (df = 6, N = 541), p = 0.021, r = 0.14); and post-EMR Site B higher median

Table 4
Pre- and post-survey results – burnout spectrum.

Study construct	Survey tool (component)			Yes n(%)	No n(%)	95% Confidence Interval (Yes)(%)	df	N	Continuity Correlation	p-value	Phi
Well-being	Maslach Burnout Inventory (sub-analysis)	Burnout	Pre	11(2%)	536 (98%)	2–2.1	1	934	4.410	0.036*	0.075
			Post	18(4.7%)	369 (95.3%)	4.6–4.7					
		Overextended	Pre	56 (10.2%)	491 (89.8%)	10.2–10.3	1	933	0.494	0.482	0.027
			Post	46 (11.9%)	340 (86.7%)	11.8–12					
		Ineffective	Pre	54(9.9%)	493 (90.1%)	9.8–10	1	934	17.237	<0.001**	0.139
			Post	76 (19.6%)	311 (80.4%)	19.5–19.8					
		Disengaged	Pre	15(2.7%)	532 (97.3%)	2.7–2.8	1	934	4.410	0.036*	−0.021
			Post	8(2.1%)	378 (97.9%)	2–2.1					
		Engaged	Pre	354 (64.7%)	193 (35.3%)	64.6–64.8	1	933	20.296	<0.001**	−0.15
			Post	192 (49.7%)	194 (50.2%)	49.6–49.9					

df = Degrees of freedom. *p < 0.05. **p < 0.01.

Table 5
Pre- and Post-electronic medical record correlations accounting for both clinical work area and site of the healthcare organisation – Spearman's Rho.

		Work satisfaction Correlation Coefficient (BCa 95% Confidence Interval)	Intention to stay Correlation Coefficient (BCa 95% Confidence Interval)	Well-being Index Correlation Coefficient (BCa 95% Confidence Interval)	Relative Autonomy Index Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Engagement) Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Burnout) Correlation Coefficient (BCa 95% Confidence Interval)	Age Correlation Coefficient (BCa 95% Confidence Interval)	Years worked Correlation Coefficient (BCa 95% Confidence Interval)	Hours worked Correlation Coefficient (BCa 95% Confidence Interval)
Intention to stay – Partial correlation Location + Site	Pre	0.315** (0.215–0.414)								
	Post	0.510** (0.414–0.601)								
Well-being Index – Partial correlation Location + Site	Pre	0.383** (0.270–0.505)	0.231** (0.142–0.325)							
	Post	0.607** (0.531–0.671)	0.270** (0.164–0.370)							
Autonomy and Competence in Technology Adoption Relative Autonomy Index – Partial correlation Location + Site	Pre	0.121* (0.027–0.222)	–	0.178** (0.089–0.266)						
	Post	0.364** (0.271–0.443)	0.218** (0.106–0.323)	0.332** (0.230–0.433)						
Maslach Burnout Inventory (Engagement) – Partial correlation Location + Site	Pre	0.137* (0.057–0.219)	0.106* (0.018–0.183)	0.111* (0.032–0.189)	0.109* (0.022–0.204)					
	Post	0.201** (0.106–0.292)	0.156* (0.063–0.255)	0.254** (0.161–0.337)	–					
Maslach Burnout Inventory (Burnout) – Partial correlation Location + Site	Pre	−0.219** (-0.320 - −0.119)	−0.176** (-0.278 - −0.075)	−0.236** (-0.327 - −0.146)	−0.119* (-0.212 - −0.033)	−0.438** (-0.484 - −0.396)				
	Post	−0.304** (-0.407 - −0.199)	−0.236** (-0.337 - −0.126)	−0.230** (-0.338 - −0.112)	–	−0.411** (-0.466 - −0.354)				
Age – Partial correlation Location + Site	Pre	−0.093* (-0.177 - −0.018)	–	–	−0.198** (-0.273 - −0.121)	–	0.092* (0.003–0.183)			
	Post	−0.182** (-0.287 - −0.068)	–	–	−0.246** (-0.338 - −0.144)	–	–			

(*continued on next page*)

Table 5 (*continued*)

		Work satisfaction Correlation Coefficient (BCa 95% Confidence Interval)	Intention to stay Correlation Coefficient (BCa 95% Confidence Interval)	Well-being Index Correlation Coefficient (BCa 95% Confidence Interval)	Relative Autonomy Index Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Engagement) Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Burnout) Correlation Coefficient (BCa 95% Confidence Interval)	Age Correlation Coefficient (BCa 95% Confidence Interval)	Years worked Correlation Coefficient (BCa 95% Confidence Interval)	Hours worked Correlation Coefficient (BCa 95% Confidence Interval)
Years worked – Partial correlation Location + Site	Pre	−0.091* (-0.166 - −0.022)	–	–	−0.245** (-0.325 - −0.164)	–	0.140* (0.045–0.231)	0.861** (0.826–0.891)		
	Post	−0.235** (-0.333 - −0.129)	−0.127* (-0.233 - −0.009)	−0.106* (-0.204 - −0.006)	−0.314** (-0.398 - −0.218)	–	0.147* (0.019–0.272)	0.881** (0.840–0.913)		
Hours worked – Partial correlation Location + Site	Pre	–	–	–	–	–	0.092* (0.000–0.183)	–	–	
	Post	–	–	–	–	−0.134* (-0.245 - −0.020)	–	–	–	

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed). Bootstrap results based on 1000 bootstrap samples. Cells that do not include data (–) are those that violated statistical assumptions (i.e. confidence interval crosses zero) and are therefore not included as they cannot be accurately interpreted.[23].

score than Site C, $\chi2 = 12.157$ (df = 5, N = 383), p = 0.037, r = 0.15).

Nurses with fewer years' work experience reported higher work satisfaction pre-EMR than those with 20–24 years' experience ($\chi2 = 22.293$ (df = 10, N = 531), p = 0.029, r = 0.15). Similarly, post-EMR higher work satisfaction was reported by younger nurses (30–39 years compared to 50–59 years, $\chi2 = 12.276$ (df = 5, N = 384), p = 0.031, r = 0.16), and those working part-time (56–64 h per fortnight compared to 72–80 h per fortnight, $\chi2 = 14.147$ (df = 5, N = 380), p = 0.047, r = 0.15).

After EMR implementation, nurses working in procedural units reported higher work satisfaction than those working on medical/surgical wards (median score 7) ($\chi2 = 23.295$ (df = 5, N = 382), p = 0.042, r = 0.15.

3.4. *Matched data sub-group analysis*

Sub-group analysis using 52 matched pre- and post-EMR surveys from the same individuals verified findings in the unmatchable larger dataset. Seven items had statistically significant findings in the same direction as the larger dataset: work satisfaction decreased (r = 0.457, p=<0.001); intention to stay decreased (r = 0.217, p = 0.027); relative autonomy decreased (r = 0.22, p = 0.024); decrease in dedication (r = 0.23, p = 0.017); reduced efficiency (r = 0.498, p=<0.001); and increase in psychological safety (r = 0.205, p = 0.037). All other items had the same direction of change post-EMR as the larger dataset except career trajectory satisfaction (non-statistically significant increase). All burnout spectrum items had the same direction of change as the larger dataset except nurses classified as overextended (non-statistically significant decrease). Sub-group results are presented as Appendices C and D.

4. Discussion

A novel aspect of this study was the concurrent examination of multiple factors of nurse well-being, work engagement, motivation to use technology and EMR experience, demonstrating multiple negative impacts on nurses associated with implementation of an organisation-wide EMR system coinciding with the SARS-CoV-2 pandemic. Post-EMR, nurses' work satisfaction decreased, they had higher intention to leave their jobs, poorer well-being and higher self-reported symptoms of burnout. These negative impacts are further illustrated by negative correlations between nurses' work satisfaction and burnout, burnout and intention to stay, and burnout and work engagement. Nurses' intention to stay, well-being, and components of work engagement (vigour, dedication) all decreased post-EMR, indicating a negative association between EMR implementation and nurse well-being and workforce retention.

A distinguishing feature of this study was the opportunity to use a natural experiment of a new organisation-wide EMR system implementation, to examine the impact of two major and concurrent changes on the nursing workforce: one planned in the form of the EMR implementation, and one unplanned in the form of the SARS-CoV-2 pandemic. Despite the unique context, findings of negative correlations between work satisfaction and burnout, burnout and intention to stay, and burnout and work engagement, and positive correlations between work satisfaction and intention to stay are all consistent with previous nursing research.[24,25] Multiple correlations between the study dimensions highlight the complex issues for implementing technology with a nursing workforce. Understanding the complex interplay of well-being, work engagement, motivation to use technology and experience using EMR can assist with targeted strategies to minimise the negative impacts of major change associated with technology implementation on the nursing workforce. Minimising negative impacts may help enhance nurse well-being, work satisfaction, engagement in using EMR, and retention.[2,26].

4.1. Well-being

In this study, nurse well-being was examined using the Maslach Burnout Inventory[16] revealing nurses' exhaustion and cynicism increased and efficiency reduced post-EMR. Nurses' well-being also decreased post-EMR as measured by the Well-Being Index.[15] These findings are similar to previous studies in which negative EMR perceptions and EMR use added to nurses' daily frustrations, and was associated with increased likelihood of burnout.[9] Nurses' self-reported burnout spectrum symptoms changed post-EMR from engaged towards ineffective and burnout, further supporting this finding[22].

Post-EMR, nurses working at a smaller hospital site had higher well-being than those at a larger site, and nurses working in procedural units or part-time had higher work satisfaction than those on medical/surgical wards. It is unclear whether these findings are due to less time working with the EMR, clinical areas with less demand (including less pandemic impact), supportive leadership structures or other contributing factors.

The healthcare organisation's first 18 months of EMR use coincided with the pandemic and associated lockdowns, surges in nursing workforce demands and psychosocial impacts. The negative impact of pandemic on nurses' physical and psychological well-being has been well documented internationally, with ongoing uncertainty increasing healthcare provider stress and anxiety.[27] Negative pandemic impacts on healthcare workers has included stress, depression and anxiety, though few (11.6%) considered leaving their jobs in one Australian study.[28] Our study identified a higher proportion of nurses with high intention to leave their roles (n = 138, 35.2%).

4.2. Work engagement

Nurses' work engagement decreased post-EMR across all measures including single item measures for work satisfaction and intention to stay, the Utrecht Work Engagement Scale[18] and career trajectory satisfaction. The negative impacts of EMR implementation on nurses' work engagement, satisfaction and intention to stay, are consistent with previous research examining EMR implementation impacts on nurses and have been related to system usability, time spent on EMR documentation or away from patients.[29–31] Also consistent with previous literature was the study finding that older nurses (in this study over 50 years) reported lower work satisfaction than their younger colleagues.[32] The potentially harmful impacts of EMR implementation on older nurses may increase their vulnerability to leave the profession, which itself has negative financial consequences as well as negative workforce and patient safety impacts with the loss of nursing experience and skillsets.[32,33] The interactions between nurses' work satisfaction, engagement and intention to stay must be monitored and minimised post-EMR in order to retain nurses and ensure the continuation of quality care delivery.[34].

4.3. Motivation to use technology and experience using EMR

Nurses' perceived competence in EMR use increased post-implementation. Although no other comparable pre- and post-studies can be found, nurses' perceived EMR competence is a known influencing factor for EMR use and subsequent patient care delivery.[35] Despite low well-being and work satisfaction scores, nurses reported comparatively higher EMR-related autonomy when completing nursing tasks, and more competence when thinking about whether the EMR impacted their life overall. Competence, autonomy and relatedness have been recognised as factors to be addressed in order to support motivation and reduce EMR-related burnout impacts.[36] Interestingly, nurses reported lower autonomy when referring to the EMR overall compared to pre-EMR, but higher autonomy when relating to how EMR impacts on nursing tasks (no pre-EMR comparison data). These results may relate to the recency of the data collection post-implementation and differs to recent research indicating decreased autonomy was a common complaint related to EMR use.[37].

4.4. Limitations

The authors acknowledge several limitations. Due to utilising the natural experiment of an EMR implementation, data were coincidentally collected pre- and post-EMR implementation as well as pre- and during the SARS-CoV-2 pandemic. Consultation with a biostatistician confirmed the inability to differentiate nurses' EMR implementation experiences from the pandemic. A unique strength of this study was the opportunity to capture real-world context of unpredictable factors influencing planned change in healthcare organisations.

Several organisational restrictions were in place due to SARS-CoV-2 that required increased correspondence via email with nursing leaders and clinical staff. A benefit of electronic survey responses was high data quality. Limited data were available on nurse retention or employment changes because many nurses were deployed to other clinical areas and supported pandemic-related activities throughout the healthcare organisation (i.e., staffing SARS-CoV-2 testing and vaccination hubs, personal and protective equipment coaches and N-95 mask fitting).

When discussing the survey with potential participants, many nurses expressed willingness to participate due to the topical nature of the project. However, the survey response rate (9.76%), comparable with a survey of a different Victorian healthcare organisation during 2020,[28] may be indicative of competing priorities within the clinical setting, particularly in the context of the SARS-CoV-2 pandemic. The project team believe the diverse nurse participants, responses from all eligible hospital sites and study findings correlating to previous research examining nurses' well-being, intention to stay, burnout, work engagement, work satisfaction and motivation to use technology (including psychosocial factors) support the potential transferability of these study findings.

5. Conclusions

Nurses' well-being, intention to stay, burnout, work engagement and satisfaction were worse post-EMR implementation in the context of the SARS-CoV-2 pandemic. Due to the pandemic, post-implementation findings cannot be definitively attributed to EMR alone. The unique timing of this study's natural experiment meant valuable data were captured both pre- and post-EMR and pre- and intra-pandemic on nurses' psychosocial well-being from an Australian healthcare organisation. Pre-EMR implementation nurses reported poor well-being but were engaged and satisfied in their work. Post-EMR implementation, nurses reported lower work satisfaction, lower intention to stay, lower well-being and higher perceived competence. This study helps to address a gap in knowledge about how an EMR implementation potentially affects nurses' work engagement and well-being. In light of the post-EMR implementation findings, next steps will include developing strategies to improve nurses' EMR experiences and psychosocial well-being, including addressing the accessibility, usefulness and perceived value of existing support from the healthcare organisation. This study contributes to the call for expanding research beyond usability and burden of EMR documentation in order to address EMR-related clinician burnout.

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7. Data availability statement

The data underlying this article cannot be shared publicly due to privacy of individuals who participated in the study. The data will be shared on reasonable request to the corresponding author.

Summary Table.

What is already known	What this study adds
• Nursing studies most often examined compliance, usability or satisfaction with the EMR system Nurses' EMR experiences of implementation and consequences for their well-being and work satisfaction are unknown	• Measures of nurses' work engagement, satisfaction, intention to stay, burnout and well-being worsened post-implementation of an organisation-wide EMR system The unique timing of the natural experiment captured data about nurses' psychosocial well-being at an Australian healthcare organisation before and after an EMR implementation and experiencing the SARS-CoV-2 pandemic Strategies are needed to improve nurses' EMR experiences and psychosocial well-being to support nurse workforce retention, productivity and quality patient care delivery Qualitative studies to explore and understand nurses' EMR experiences can further reduce the gap in knowledge about EMR burden and workforce impacts

CRediT authorship contribution statement

Rebecca M. Jedwab: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Resources, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition. **Alison M. Hutchinson:** Conceptualization, Methodology, Validation, Resources, Writing – review & editing, Visualization, Supervision, Project administration. **Elizabeth Manias:** Conceptualization, Methodology, Validation, Resources, Writing – review & editing, Visualization, Supervision, Project administration. **Rafael A. Calvo:** Conceptualization, Methodology, Resources, Writing – review & editing. **Naomi Dobroff:** Conceptualization, Methodology, Resources, Writing – review & editing, Visualization, Supervision, Project administration. **Bernice Redley:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Resources, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration.

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Declarations of interest

None.

Appendices A. . Pre-electronic medical record survey data correlations and partial correlations – Spearman's Rho

	Work satisfaction Correlation Coefficient (BCa 95% Confidence Interval)	Intention to stay Correlation Coefficient (BCa 95% Confidence Interval)	Well-being Index Correlation Coefficient (BCa 95% Confidence Interval)	Autonomy and Competence in Technology Adoption – Relative Autonomy Index Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Engagement) Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Burnout) Correlation Coefficient (BCa 95% Confidence Interval)	Age Correlation Coefficient (BCa 95% Confidence Interval)	Years worked Correlation Coefficient (BCa 95% Confidence Interval)	Hours worked Correlation Coefficient (BCa 95% Confidence Interval)
Intention to stay	0.382** (0.306–0.457)								
Intention to stay Partial correlation – Location	0.315** (0.226–0.409)								
Intention to stay Partial correlation – Site	0.315** (0.217–0.412)								
Intention to stay Partial correlation – Location + Site	0.315** (0.215–0.414)								
Well-being Index %	0.392** (0.309–0.479)	0.219** (0.133–0.306)							
Well-being Index % Partial correlation – Location	0.383** (0.275–0.484)	0.229** (0.132–0.326)							
Well-being Index % Partial correlation – Site	0.381** (0.272–0.483)	0.231** (0.136–0.315)							

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	Work satisfaction Correlation Coefficient (BCa 95% Confidence Interval)	Intention to stay Correlation Coefficient (BCa 95% Confidence Interval)	Well-being Index Correlation Coefficient (BCa 95% Confidence Interval)	Autonomy and Competence in Technology Adoption – Relative Autonomy Index Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Engagement) Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Burnout) Correlation Coefficient (BCa 95% Confidence Interval)	Age Correlation Coefficient (BCa 95% Confidence Interval)	Years worked Correlation Coefficient (BCa 95% Confidence Interval)	Hours worked Correlation Coefficient (BCa 95% Confidence Interval)
Well-being Index % Partial correlation – Location + Site	0.383** (0.270–0.505)	0.231** (0.142–0.325)							
Relative Autonomy Index	0.163** (0.069–0.258)	–	0.191** (0.095–0.277)						
Relative Autonomy Index Partial correlation – Location	0.121** (0.025–0.215)	–	0.183** (0.096–0.263)						
Relative Autonomy Index Partial correlation – Site	0.118* (0.025–0.210)	–	0.181** (0.095–0.267)						
Relative Autonomy Index Partial correlation – Location + Site	0.121* (0.027–0.222)	–	0.178** (0.089–0.266)						
Maslach Burnout Inventory (Engagement)	0.147** (0.059–0.233)	0.112* (0.033–0.198)	0.104* (0.024–0.186)	0.121** (0.039–0.208)					
Maslach Burnout Inventory (Engagement) Partial correlation – Location	0.136* (0.040–0.229)	0.108* (0.017–0.198)	0.107* (0.018–0.192)	0.100* (0.015–0.181)					
Maslach Burnout Inventory (Engagement)– Partial correlation – Site	0.135* (0.056–0.210)	0.106* (0.028–0.189)	0.113* (0.037–0.191)	0.112* (0.029–0.194)					
Maslach Burnout Inventory (Engagement) Partial correlation – Location + Site	0.137* (0.057–0.219)	0.106* (0.018–0.183)	0.111* (0.032–0.189)	0.109* (0.022–0.204)					
Maslach Burnout Inventory (Burnout)	−0.189** (-0.277 - −0.097)	−0.183** (-0.271 - −0.092)	−0.227** (-0.315 - −0.143)	−0.109* (-0.191 - −0.026)	−0.443** (-0.489 - −0.400)				
Maslach Burnout Inventory (Burnout) Partial correlation – Location	−0.217** (-0.307 - −0.134)	−0.178** (-0.267 - −0.086)	−0.230** (-0.318 - −0.136)	−0.108* (-0.191 - −0.017)	−0.442** (-0.489 - −0.397)				
Maslach Burnout Inventory (Burnout) Partial correlation – Site	−0.217** (-0.306 - −0.116)	−0.176** (-0.262 - −0.087)	−0.237** (-0.326 - −0.142)	−0.121* (-0.206 - −0.028)	−0.439** (-0.487 - −0.396)				
Maslach Burnout Inventory (Burnout) Partial correlation – Location + Site	−0.219** (-0.320 - −0.119)	−0.176** (-0.278 - −0.075)	−0.236** (-0.327 - −0.146)	−0.119* (-0.212 - −0.033)	−0.438** (-0.484 - −0.396)				

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	Work satisfaction Correlation Coefficient (BCa 95% Confidence Interval)	Intention to stay Correlation Coefficient (BCa 95% Confidence Interval)	Well-being Index Correlation Coefficient (BCa 95% Confidence Interval)	Autonomy and Competence in Technology Adoption – Relative Autonomy Index Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Engagement) Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Burnout) Correlation Coefficient (BCa 95% Confidence Interval)	Age Correlation Coefficient (BCa 95% Confidence Interval)	Years worked Correlation Coefficient (BCa 95% Confidence Interval)	Hours worked Correlation Coefficient (BCa 95% Confidence Interval)
Age	−0.101*	–	–	−0.143**	–	0.088*			
	(-0.196 - −0.004)			(-0.224 - −0.053)		(0.006–0.179)			
Age Partial correlation – Location	−0.091*	–	–	−0.176**	–	0.104*			
	(-0.174 - −0.008)			(-0.260 - −0.093)		(0.020–0.188)			
Age Partial correlation – Site	−0.098*	–	–	−0.189**	–	0.085*			
	(-0.173 - −0.017)			(-0.270 - −0.104)		(0.003–0.172)			
Age Partial correlation – Location + Site	−0.093*	–	–	−0.198**	–	0.092*			
	(-0.177 - −0.018)			(-0.273 - −0.121)		(0.003–0.183)			
Years worked	−0.131**	–	–	−0.210**	–	0.134**	0.862**		
	(-0.219 - −0.032)			(-0.292 - −0.115)		(0.058–0.218)	(0.827–0.891)		
Years worked Partial correlation – Location	−0.089*	–	–	−0.229**	–	0.148*	0.862**		
	(-0.167 - −0.011)			(-0.311 - −0.150)		(0.054–0.236)	(0.829–0.894)		
Years worked Partial correlation – Site	−0.093*	–	–	−0.240**	–	0.135*	0.861**		
	(-0.169 - −0.014)			(-0.321 - −0.161)		(0.053–0.217)	(0.830–0.893)		
Years worked Partial correlation – Location + Site	−0.091*	–	–	−0.245**	–	0.140*	0.861**		
	(-0.166 - −0.022)			(-0.325 - −0.164)		(0.045–0.231)	(0.826–0.891)		
Hours worked	–	–	–	–	–	–	−0.094*	−0.113*	
							(-0.182 - −0.007)	(-0.199 - −0.026)	
Hours worked Partial correlation – Location	–	–	–	–	–	–	–	−0.099*	
								(-0.200 - −0.002)	
Hours worked Partial correlation – Site	–	–	–	–	–	–	–	–	
Hours worked Partial correlation – Location + Site	–	–	–	–	–	0.092*	–	–	
						(0.000–0.183)			

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed). Bootstrap results based on 1000 bootstrap samples. Cells that do not include data are those that violated assumptions and are not included as they cannot be accurately interpreted.

Appendices B. . Post-electronic medical record survey data correlations and partial correlations – Spearman's Rho

	Work satisfaction Correlation Coefficient (BCa 95% Confidence Interval)	Intention to stay Correlation Coefficient (BCa 95% Confidence Interval)	Well-being Index Correlation Coefficient (BCa 95% Confidence Interval)	Autonomy and Competence in Technology Adoption – Relative Autonomy Index Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Engagement) Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Burnout) Correlation Coefficient (BCa 95% Confidence Interval)	Age Correlation Coefficient (BCa 95% Confidence Interval)	Years worked Correlation Coefficient (BCa 95% Confidence Interval)	Hours worked Correlation Coefficient (BCa 95% Confidence Interval)
Intention to stay	0.505** (0.419–0.584)								
Intention to stay Partial correlation – Location	0.503** (0.415–0.596)								
Intention to stay Partial correlation – Site	0.515** (0.416–0.596)								
Intention to stay Partial correlation – Location + Site	0.510** (0.414–0.601)								
Well-being Index %	0.609** (0.532–0.679)	0.284** (0.183–0.385)							
Well-being Index % Partial correlation – Location	0.607** (0.533–0.672)	0.260** (0.156–0.364)							
Well-being Index % Partial correlation – Site	0.613** (0.540–0.676)	0.276** (0.180–0.366)							
Well-being Index % Partial correlation – Location + Site	0.607** (0.531–0.671)	0.270** (0.164–0.370)							
Relative Autonomy Index	0.344** (0.250–0.441)	0.220** (0.125–0.317)	0.323** (0.221–0.424)						
Relative Autonomy Index Partial correlation – Location	0.364** (0.264–0.460)	0.216** (0.115–0.321)	0.331** (0.237–0.421)						
Relative Autonomy Index Partial correlation – Site	0.373** (0.266–0.465)	0.223** (0.116–0.325)	0.339** (0.243–0.428)						
Relative Autonomy Index Partial correlation – Location + Site	0.364** (0.271–0.443)	0.218** (0.106–0.323)	0.332** (0.230–0.433)						
Maslach Burnout Inventory (Engagement)	0.205** (0.107–0.293)	0.136* (0.023–0.233)	0.247** (0.145–0.347)	–					
Maslach Burnout Inventory (Engagement) Partial correlation – Location	0.201** (0.100–0.296)	0.145* (0.040–0.237)	0.256** (0.159–0.345)	–					
Maslach Burnout Inventory (Engagement)– Partial correlation – Site	0.207** (0.111–0.306)	0.159* (0.053–0.261)	0.258** (0.170–0.349)	0.096 (0.003–0.196)					
Maslach Burnout Inventory				–					

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	Work satisfaction Correlation Coefficient (BCa 95% Confidence Interval)	Intention to stay Correlation Coefficient (BCa 95% Confidence Interval)	Well-being Index Correlation Coefficient (BCa 95% Confidence Interval)	Autonomy and Competence in Technology Adoption – Relative Autonomy Index Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Engagement) Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Burnout) Correlation Coefficient (BCa 95% Confidence Interval)	Age Correlation Coefficient (BCa 95% Confidence Interval)	Years worked Correlation Coefficient (BCa 95% Confidence Interval)	Hours worked Correlation Coefficient (BCa 95% Confidence Interval)
(Engagement) Partial correlation – Location + Site	0.201** (0.106–0.292)	0.156* (0.063–0.255)	0.254** (0.161–0.337)						
Maslach Burnout Inventory (Burnout)	−0.276** (-0.376 - −0.166)	−0.215** (-0.313 - −0.106)	−0.200** (-0.306 - −0.097)	–	−0.409** (-0.471 - −0.352)				
Maslach Burnout Inventory (Burnout) Partial correlation – Location	−0.304** (-0.415 - −0.194)	−0.233** (-0.350 - −0.101)	−0.230** (-0.329 - −0.129)	–	−0.410** (-0.464 - −0.356)				
Maslach Burnout Inventory (Burnout) Partial correlation – Site	−0.300** (-0.404 - −0.183)	−0.236** (-0.347 - −0.117)	−0.229** (-0.339 - −0.115)	–	−0.411** (-0.468 - −0.352)				
Maslach Burnout Inventory (Burnout) Partial correlation – Location + Site	−0.304** (-0.407 - −0.199)	−0.236** (-0.337 - −0.126)	−0.230** (-0.338 - −0.112)	–	−0.411** (-0.466 - −0.354)				
Age	−0.129* (-0.228 - −0.027)	–	–	−0.193** (-0.286 - −0.095)	–	–			
Age Partial correlation – Location	−0.181** (-0.286 - −0.078)	−0.101 (-0.203 - −0.004)	–	−0.242** (-0.337 - −0.149)	–	–			
Age Partial correlation – Site	−0.153** (-0.253 - −0.043)	–	–	−0.228** (-0.312 - −0.142)	–	–			
Age Partial correlation – Location + Site	−0.182** (-0.287 - −0.068)	–	–	−0.246** (-0.338 - −0.144)	–	–			
Years worked	−0.203** (-0.303 –0.107)	–	–	−0.266** (-0.352 - −0.174)	–	0.114* (0.009–0.217)	0.881** (0.846–0.911)		
Years worked Partial correlation – Location	−0.234** (-0.327 - −0.138)	−0.116* (-0.224 - −0.016)	−0.110* (-0.200 - −0.015)	−0.311** (-0.402 - −0.216)	–	0.144* (0.043–0.253)	0.883** (0.848–0.915)		
Years worked Partial correlation – Site	−0.214** (-0.311 - −0.112)	−0.119* (-0.230 - −0.003)	−0.095 (-0.187 - −0.003)	−0.302** (-0.378 - −0.224)	–	0.146* (0.040–0.259)	0.882** (0.840–0.914)		
Years worked Partial correlation – Location + Site	−0.235** (-0.333 - −0.129)	−0.127* (-0.233 - −0.009)	−0.106* (-0.204 - −0.006)	−0.314** (-0.398 - −0.218)	–	0.147* (0.019–0.272)	0.881** (0.840–0.913)		
Hours worked	0.137* (0.029–0.238)	–	–	–	−0.127* (-0.219 –0.039)	–	–	−0.115* (-0.217 –0.016)	
Hours worked Partial	–	–	–	–	−0.128* (-0.222 –0.023)	–	–	−0.093	

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	Work satisfaction Correlation Coefficient (BCa 95% Confidence Interval)	Intention to stay Correlation Coefficient (BCa 95% Confidence Interval)	Well-being Index Correlation Coefficient (BCa 95% Confidence Interval)	Autonomy and Competence in Technology Adoption – Relative Autonomy Index Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Engagement) Correlation Coefficient (BCa 95% Confidence Interval)	Maslach Burnout Inventory (Burnout) Correlation Coefficient (BCa 95% Confidence Interval)	Age Correlation Coefficient (BCa 95% Confidence Interval)	Years worked Correlation Coefficient (BCa 95% Confidence Interval)	Hours worked Correlation Coefficient (BCa 95% Confidence Interval)
correlation – Location								(-0.198 –0.005)	
Hours worked Partial correlation – Site	–	–	–	–	−0.129* (-0.234 - −0.031)	–	–	–	
Hours worked Partial correlation – Location + Site	–	–	–	–	−0.134* (-0.245 - −0.020)	–	–	–	

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed). Bootstrap results based on 1000 bootstrap samples. Cells that do not include data are those that violated assumptions and are not included as they cannot be accurately interpreted.

Appendices C. . Sub-group analysis of matched pre- and post-survey data (n = 52)

		Mean (SD)	95% Confidence Interval	Median (IQRs)	Z value	p-value	r
Work satisfaction	Pre	8.37(1.39)	7.99–8.75	8(8–9.75)	−4.658	<0.001**	0.457
	Post	7.08(1.74)	6.61–7.55	7.5(6–8)			
Intention to stay	Pre	8.63(2.06)	8.07–9.19	10(8–10)	−2.208	0.027*	0.217
	Post	7.90(2.70)	7.17–8.63	9(6.25–10)			
Well-being Index %	Pre	62.92 (15.46)	58.72–67.12	60(52–72)	−1.820	0.069	
	Post	58.38 (18.68)	53.30–63.46	64(44–75)			
Autonomy and Competence in Technology Adoption – Perceived competence	Pre	3.30(1.04)	3.02–3.58	3.5(3–4)	−1.371	0.170	
	Post	3.50(1.16)	3.18–3.82	3.5(3–4.5)			
Autonomy and Competence in Technology Adoption – Relative Autonomy Index	Pre	0.10(1.29)	−0.25–0.45	0.08(-0.83–1)	−2.257	0.024*	0.22
	Post	−0.26 (1.24)	−0.60–0.08	−0.25(-1–0.5)			
Utrecht Work Engagement Scale Vigour	Pre	3.25(1.05)	2.96–3.54	3(3–4)	−1.334	0.182	
	Post	3.02(0.98)	2.75–3.29	3(2.25–4)			
Utrecht Work Engagement Scale Dedication	Pre	4.38(0.99)	4.11–4.65	4(4–5)	−2.383	0.017*	0.23
	Post	4.02(1.00)	3.75–4.29	4(3–5)			
Utrecht Work Engagement Scale Absorption	Pre	4.31(0.92)	4.06–4.56	4(4–5)	−0.690	0.490	
	Post	4.19(1.01)	3.92–4.46	4(3–5)			
Maslach Burnout Inventory Exhaustion	Pre	1.89(0.93)	1.64–2.14	1.67 (1.33–2.33)	−1.223	0.221	
	Post	2.12(1.07)	1.83–2.41	1.67 (1.33–2.67)			
Maslach Burnout Inventory Cynicism	Pre	1.38(0.93)	1.13–1.63	1.33 (0.75–1.92)	−0.516	0.606	
	Post	1.54(0.93)	1.29–1.79	1.33 (0.67–2.25)			
Maslach Burnout Inventory Reduced Efficiency	Pre	1.59(0.91)	1.34–1.84	1.5(1–2)	−5.079	<0.001**	0.498
	Post	2.47(0.82)	2.25–2.69	2.33(2–3)			
Psychological Safety	Pre	2.88(0.79)	2.67–3.09	3(2.5–3.5)	−2.091	0.037*	0.205
	Post	3.13(0.94)	2.87–3.39	3.5(2.5–3.5)			
Career Trajectory Satisfaction	Pre	3.62(0.84)	3.39–3.85	4(3–4)	−0.122	0.903	
	Post	3.63(0.84)	3.40–3.86	4(3–4)			

*p-value < 0.05. **p-value < 0.01. r = 0.1 = small effect size, 0.3 = medium effect, 0.5 = large effect size.

Appendices D. . Sub-group analysis of burnout spectrum items (n = 52)

		Yes n (%)	No n (%)	95% Confidence Interval (Yes) (%)	df	Test statistic	p-value (asymptotic)
Burnout	Pre	0(0)	52(100)	0–0	1	0.000	1.000
	Post	1(1.9)	51(98.1)	1.9–2.0			
Overextended	Pre	5(9.6)	47(90.4)	9.5–9.7	1	0.000	1.000
	Post	4(7.7)	48(92.3)	7.6–7.8			

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		Yes n (%)	No n (%)	95% Confidence Interval (Yes) (%)	df	Test statistic	p-value (asymptotic)
Ineffective	Pre	5(9.6)	47(90.4)	9.5–9.7	1	4.083	0.043*
	Post	13(25)	39(75)	24.9–25.1			
Disengaged	Pre	1(1.9)	51(98.1)	1.9–2.0	1	0.000	1.000
	Post	0(0)	52(100)	0–0			
Engaged	Pre	38(73.1)	14(26.9)	73.0–73.2	1	2.450	0.118
	Post	30(57.7)	22(42.3)	57.5–57.8			

df = Degrees of freedom. *p-value < 0.05.

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