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Understanding burnout and engagement during medical residency: a multifactorial and longitudinal approach

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Abstract

Background The residency period constitutes a critical phase of medical training, during which increasing clinical and professional responsibilities influence residents' well-being. Grounded in the Job Demands-Resources model, this study investigates how burnout and engagement evolve during this period and examines their associations with specific demands, resources, and personality traits.

Methods Between 2021 and 2025, data were collected annually via an online survey administered to medical residents from five Belgian universities ($n = 1068$). Burnout dimensions (i.e., emotional exhaustion, cynicism and reduced professional efficacy) and engagement were assessed alongside their associations with demands, resources, and personality traits. Linear mixed-effects models estimated the relationships between independent and dependent variables.

Results The findings show that emotional exhaustion and cynicism modestly but gradually increased over time, while engagement slightly declined and professional efficacy remained stable. Work–home conflict showed the strongest association with the outcomes, while meaningfulness was identified as the most prominent resource and neuroticism as the strongest personal factor consistently linked to all outcome variables.

Conclusions These findings highlight the urgent need for structural interventions within residency programs to address key demands and strengthen meaningful work, while recognizing neuroticism as a vulnerability factor in protecting residents' well-being.

Clinical trial number Not applicable.

Keywords Medical education, Burnout, Engagement, Longitudinal, Residency, Healthcare

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Background

The residency period constitutes a demanding phase of medical training where future physicians gain clinical experience and focus on their professional development [1–4]. While it offers growth opportunities as residents adapt to new roles and clinical environments, it also presents emotional, cognitive, and physical demands that may affect their well-being and increase burnout [1, 4]. Former studies provide first evidence for an increase in burnout from pre-clinical years to residency, with residents showing higher levels compared to pre-clinical students and more experienced physicians [1, 4–11]. In addition, Dyrbye et al. (2014) found that burnout rates in residents are higher than those observed in the general population ($p<0.001$) [4].

Burnout is typically defined and investigated as a multidimensional model comprising three main dimensions: emotional exhaustion, depersonalization or cynicism, and reduced professional efficacy [12–15]. In contrast, engagement, is a positive, fulfilling work-related state of mind, defined by vigour, dedication, and absorption [16, 17]. Engaged individuals typically demonstrate sustained energy and enthusiastic involvement, which are strongly linked to improved work outcomes and well-being [18]. During residency, burnout has been associated with adverse outcomes including reduced performance, medical errors and dropout, whereas engagement may serve as a protective variable [4, 19–24].

Despite increasing attention to burnout and engagement, systematic evidence on how these outcomes develop across residency years remains limited. The present study examines the evolution of burnout dimensions and engagement across medical residency years to exploratively characterize temporal patterns. We hypothesize (Hypothesis 1) that burnout dimensions will increase, while engagement will decline as residents progress through their training, consistent with longitudinal stress accumulation patterns observed in prior studies [5–7, 25].

Beyond investigating the evolution of burnout and engagement across medical residency years, a second objective of the present study is to identify demands and resources that are most strongly associated with burnout and engagement across different residency phases. The Job Demands-Resources (JD-R) model offers a comprehensive theoretical framework for understanding the development of burnout and engagement [16, 26–28]. According to this model, job demands such as cognitive demands, workload, emotional demands, work-home conflict, staffing inadequacies and role conflict contribute to increased burnout among residents [29–32]. Conversely, job resources such as meaningfulness, learning opportunities, a supportive learning environment, social support from peers and supervisors, and control over working time (or autonomy), stimulate engagement and reduce burnout [2, 29–31]. The JD-R model also recognizes the influence of personality traits. Among these, neuroticism (i.e. a tendency to experience negative affect), perfectionistic strivings (i.e. setting high personal standards), and perfectionistic concerns (i.e. fear of making mistakes, self-criticism) have shown associations with both burnout and engagement [33–36].

Despite growing attention to contextual and personal factors influencing burnout and engagement in medical residency, evidence remains limited on which variables are most influential across all residency years, hindering the development of tailored interventions. Moreover, prior research has rarely integrated both work-contextual factors (i.e., job demands and job resources) and personal factors within a single analytical model, limiting a comprehensive understanding of how these domains influence burnout and engagement [6, 14]. Based on prior research, we hypothesize (Hypothesis 2) that when simultaneously accounting for multiple demands, resources and personality traits, workload and work-home conflict will be key demands associated with burnout and engagement, while meaningfulness and learning opportunities will be relevant resources [11, 32, 37–39]. In addition, we expect neuroticism to be a strong influential personality-related factor [11, 34, 40, 41].

Methods

Study design and setting

This study is embedded in the WeMeds research project (www.wemeds.be) and received approval from the Ethics Committee Research UZ/KU Leuven in April 2021 (S64150). All participants provided written informed consent prior to enrolment. The study employed a prospective repeated-measures design, with data collected via a self-administered online survey. The survey, conducted in Dutch, was distributed annually over four consecutive waves, each open from October to February: T0 (2021–2022), T1 (2022–2023), T2 (2023–2024), and T3 (2024–2025).

Population and recruitment

Medical residents from all five medical faculties in Flanders (Belgium) were invited to participate: University of Leuven (KU Leuven), Free University of Brussels (VUB), University of Hasselt (UH), University of Ghent (UG), and University of Antwerp (UA). Inclusion criteria included being 18 years or older, Dutch-speaking, and enrolled as a resident in any of the residency years. In Belgium, hospital-oriented residency programs last between four and six years, whereas General Practice (GP) residency lasts three years and takes place primarily in general practices.

Recruitment utilized both direct and indirect online channels, including emails, the WeMeds website, event flyers, and various social media platforms. Interested individuals could register online immediately upon invitation, enabling survey completion and automatic notification for subsequent measurement moments. An open cohort design was implemented, allowing registered participants to be invited annually for follow-up measurements, while also permitting the enrolment of new participants at each measurement wave.

Data collection

The data were collected using a survey composed of items from previously published and validated scales, ensuring methodological robustness and scientific validity.

Outcomes

To measure "Burnout", we assessed three main burnout dimensions (i.e., emotional exhaustion, cynicism, and professional efficacy) using the Dutch version of the MBI: the "Utrecht Burnout Scale – Contact-based professions (UBOS-C)" (20 items) [42]. The internal consistency, measured by Cronbach's alpha, was for emotional exhaustion 0.91, 0.77 for cynicism and 0.83 for professional efficacy. "Engagement" was measured using the 9-item "Utrecht Work Engagement Scale" [43]. Respondents rated the frequency of their experiences using a 7-point Likert scale, ranging from "never" (0) to "every day" [6]. Cronbach's alpha for engagement was 0.93.

Demands

"Cognitive demands" (4 items), "Workload" (4 items), "Work-Home Conflict" (4 items), and "Emotional demands" (3 items) were measured using corresponding scales from the Dutch version of the Copenhagen Psychosocial Questionnaire III (COPSOQ III) [44]. Items were rated on a 5-point Likert scale from "never" (0) to "always" [4]. Cronbach's alpha was 0.71 for cognitive demands, 0.87 for workload, 0.93 for work-home conflict, and 0.81 for emotional demands. "Staffing" (4 items) was assessed using the corresponding scale of the "Hospital Survey on Patient Safety Culture" [45], which measures perceptions of whether there are sufficient permanent staff to manage the workload. Responses were rated on a 5-point Likert scale from "Completely disagree" (0) to "Completely agree" [4]. Cronbach's alpha was 0.75 for staffing. "Role conflict" (4 items) was measured with the "Short Inventory to Monitor Psychosocial Hazards" [46], was rated on a 4-point Likert scale from "never" (0) to "always" [3], with a Cronbach's alpha of 0.77.

Resources

"Meaningfulness" (2 items), "Learning opportunities" (3 items), "Control over working time" (5 items), "Social support from peers" (3 items), and "Social support from supervisor" (3 items) were assessed using the corresponding scales from the Dutch COPSOQ III [44]. Meaningfulness achieved a Cronbach's alpha of 0.88, learning opportunities of 0.87, control over working time of 0.72, social support from peers of 0.79, and social support from supervisor of 0.86. The "Learning environment" (2 items) was measured using the corresponding scales of the "Dutch Residency Educational Climate Test" [47]. All items were rated on a 5-point Likert scale from "never" (0) to "always" [4]. Cronbach's alpha was 0.84.

Personality traits

"Perfectionism" (8 items) was assessed using the "Frost Multidimensional Perfectionism Scale - Brief (FMPS-B)" [48], which includes perfectionistic strivings (4 items) and perfectionistic concerns (4 items). Responses were rated on a 5-point Likert scale from "totally disagree" [1] to "totally agree" [5]. For perfectionistic strivings, Cronbach's alpha was 0.87 and for perfectionistic concerns this was 0.81. Further, we measured "Neuroticism" (3 items) with the 3-item neuroticism scale from the Big Five Inventory-Extra Short Form (BFI-XS) [49]. The Dutch versions were obtained via back-translation [50]. Neuroticism had a Cronbach's alpha of 0.77.

Statistical analysis

All analyses and visualizations were conducted using R studio, version 4.3.0 [51]. Missing data resulted from participant drop-out within one survey, attrition across measurement waves, and the open-cohort design. In accordance with the recommendations of Newman (2014), the proportions of complete and partial respondents were evaluated prior to analysis to characterize missing-data patterns and to avoid reliance on complete-case analyses [52]. Next, patterns of missingness were examined by comparing response rates across measurement waves and residency years. All participants who completed at least one survey were included to ensure sufficient statistical power. To examine whether data were Missing Completely At Random (MCAR), independent-samples t-tests compared participants who provided data at multiple measurement waves with those who responded only once. Subsequently, Linear Mixed-effects Models (LMM) were estimated using full information maximum likelihood (FIML), which appropriately accommodates missing data under missing-at-random assumptions (MAR) and is recommended when ≥ 10% of the respondents provide partial data [6, 52].

Further, descriptive statistics were computed to provide a detailed overview of participants' characteristics. Likert-scale responses were treated as continuous variables to permit the use of LMMs, consistent with established practices in medical education research [53]. Descriptive

analyses included calculating means and standard deviations for all study variables, and Cronbach's alpha coefficients were estimated to assess the internal consistency reliability of the multi-item scales. The distributional properties of the outcome variables were evaluated through visual inspection of histograms and Q–Q plots, as well as by examining skewness and kurtosis values to assess approximate normality [54]. Pearson correlation coefficients were calculated to examine the strength and direction of associations between independent and dependent variables. Statistical significance was evaluated using a two-sided p-value threshold of 0.05, and correlation coefficients of ≥ 0.30 were interpreted as reflecting at least moderate associations [55].

LMMs were used to model changes in in emotional exhaustion, cynicism, professional efficacy, and engagement across residency years (Hypothesis 1), while accounting for the hierarchical structure of the data and repeated observations within participants. Separate models were estimated for each outcome variable using participants' mean scale scores. Fixed effects included residency year, gender, and specialism (GP versus other residents). To account for within-subject dependency over time, participant-specific random intercepts and random slopes for measurement year were included. To test Hypothesis 2, additional LMMs were estimated to assess associations between demands, resources, personality traits, and outcomes. These models included the same covariates as above, with demands, resources, and personality traits added as fixed effects. Random effects again accounted for repeated measurements nested within participants. Independent variables were centered and scaled for interpretability. Model assumptions were evaluated through inspection of residual histograms and Q–Q plots. Multicollinearity among variables was assessed using variance inflation factors (VIFs) derived from the fixed-effects components of the models. In addition, interaction terms and non-linear effects were explored to assess potential relationships and curvilinear associations between demands, resources, personality traits, and the outcome variables. The inclusion of random intercepts and slopes was evaluated to ensure adequate model fit and to account for within-subject dependence. Statistical significance was set at $p < 0.05$ with Benjamini-Hochberg correction for multiple comparisons [56].

Results

Sociodemographic information and descriptives

In total, 775 unique participants contributed 1068 responses. The mean participant age was 27 years (SD = 3.18). Of the sample, 69.57% ($n = 743$) was female, and 93.1% ($n = 994$) reported no children. The minority of participants were GP residents (22.5%, $n = 240$), and the majority were other residents (77.5%, $n = 828$). *Supplementary Table S.1* presents the sociodemographic characteristics, *Supplementary Table S.2* provides information on the specialisms per residency year, *Supplementary Table S.3* gives the outcome variables, including means, SD's, score ranges, skewness, kurtosis and Cronbach's alpha, and *Supplementary Table S.4* contains the Pearson correlation matrix. At the response level, 90% of responses were complete ($n = 961$; full responses), whereas 10% contained missing data ($n = 107$; partial responses).

The sample was unevenly distributed across residency years, with most responses originating for year 1 ($n = 298$) and progressively fewer participants in subsequent years (year 2: $n = 255$; year 3: $n = 199$; year 4: $n = 168$; year 5: $n = 108$; year 6: $n = 40$). Although anticipated, given that GP residency lasts three years and earlier years typically include larger cohorts due to training attrition, this resulted in limited statistical power in year six. Response counts were relatively stable across measurement waves: T0 ($n = 270$), T1 ($n = 291$), T2 ($n = 287$) and T3 ($n = 220$). *Supplementary Table S.5* shows a cross-table of participants by measurement wave and residency year.

Participant-level retention across waves was limited. Of the total sample, 564 participants completed one measurement only, 143 completed two waves, 54 completed three waves, and 14 completed all four waves. Attrition t-tests reported that those with ≥2 measurements reported slightly higher emotional exhaustion, $t(466) = 2.50$, $p = 0.01$, $d = 0.20$, compared with participants who completed only one measurement, but did not differ in age, gender, specialism, cynicism, professional efficacy, or engagement (all ps > 0.05; see *Supplementary Table S.6*). Diagnostic checks indicated no major assumption violations: residuals were approximately normally distributed and all VIFs were below 3, suggesting no problematic multicollinearity.

Evolution of burnout dimensions and engagement

LMMs were used to examine changes over residency years for emotional exhaustion, cynicism, professional efficacy, and engagement (Hypothesis 1). The reference group for all analyses were first year residents. For emotional exhaustion, results indicate a significant but modest increase for second-year ($\beta = 0.325$, $SE = 0.086$, $p < 0.001$), third-year ($\beta = 0.347$, $SE = 0.097$, $p < 0.001$), fourth-year ($\beta = 0.312$, $SE = 0.114$, $p < 0.01$), and fifth-year residents ($\beta = 0.477$, $SE = 0.135$, $p < 0.001$). Gender was identified as a significant determinant, with higher emotional exhaustion reported by female residents ($\beta = 0.253$, $SE = 0.102$, $p < 0.05$); while speciality (GP versus other residents) was not significant. For cynicism, an LMM indicated slight increases in year 2 ($\beta = 0.199$, $SE = 0.083$, $p < 0.05$), year 3 ($\beta = 0.261$, $SE = 0.092$, $p < 0.01$), year 4

(β = 0.270, SE = 0.108, $p < 0.01$), and year 5 (β = 0.316, SE = 0.127, $p < 0.01$). Gender was a significant variable for cynicism, with male residents reporting higher levels compared to female residents (β = -0.374, SE = 0.093, $p < 0.001$). In addition, being a GP resident was associated with lower levels of cynicism compared to other residents (β = -0.300, SE = 0.107, $p < 0.01$). For professional efficacy, analyses indicated no significant increases or decreases ($p < 0.05$). Gender was not significant, while being a GP resident was associated with higher levels of professional efficacy compared to other residents (β = -0.226, SE = 0.076, $p < 0.01$). For engagement, LMM indicated significant modest decreases in engagement in year 2 (β = -0.328, SE = 0.073, $p < 0.001$), year 3 (β = -0.345, SE = 0.083, $p < 0.001$), year 4 (β = -0.493, SE = 0.096, $p < 0.001$), year 5 (β = -0.592, SE = 0.113, $p < 0.001$), and year 6 (β = -0.394, SE = 0.175, $p < 0.05$). Gender was a significant variable, with male residents reporting higher levels compared to female residents (β = -0.211, SE = 0.081, $p < 0.01$), while specialism was not significant. Figure 1 displays the model-based predicted means of emotional exhaustion, cynicism, professional efficacy and engagement across residency years; and *Supplementary Table S.7* shows the results of the above-mentioned LMMs.

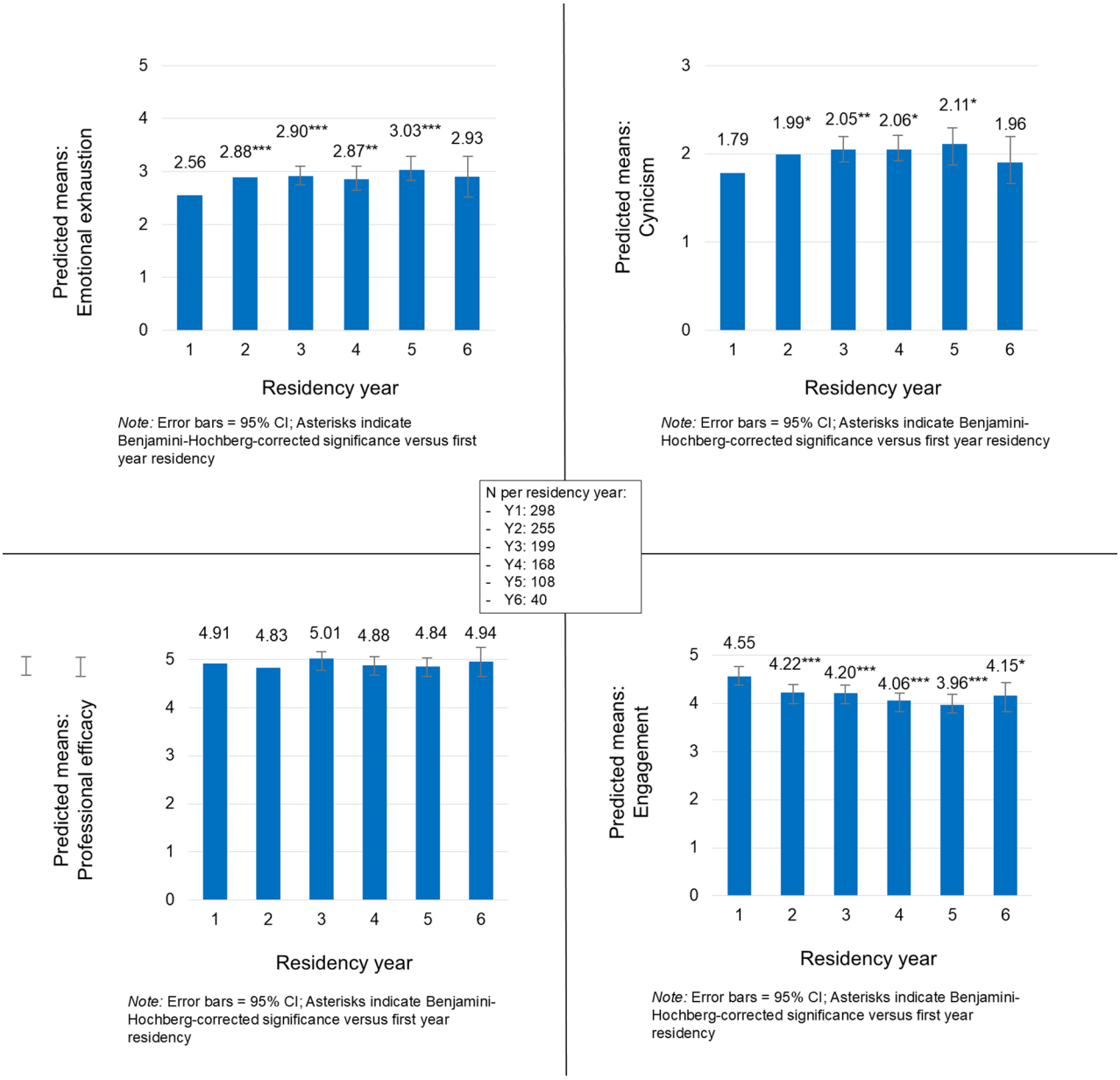

Fig. 1 Predicted means of emotional exhaustion, cynicism, professional efficacy and engagement

Main demands, resources and personality traits

Additional LMMs were estimated to identify key variables associated with the outcome variables across residency years (Hypothesis 2). For emotional exhaustion, the significant variables included workload (β = 0.110, SE = 0.031, $p < 0.001$), work-home conflict (β = 0.537, SE = 0.036, $p < 0.001$), emotional demands (β = 0.152, SE = 0.029, $p < 0.001$), role conflict (β = 0.152, SE = 0.031, $p < 0.001$), meaningfulness (β = -0.103, SE = 0.029, $p < 0.001$) and neuroticism (β = 0.355, SE = 0.032, $p < 0.001$). For cynicism, an LMM showed that associated variables were work-home conflict (β = 0.292, SE = 0.046, $p < 0.001$), emotional demands (β = 0.087, SE = 0.037, $p < 0.05$), staffing (β = 0.137, SE = 0.039, $p < 0.001$), role conflict (β = 0.120, SE = 0.040, $p < 0.05$), meaningfulness (β = -0.123, SE = 0.037, $p < 0.001$), neuroticism (β = 0.191, SE = 0.041, $p < 0.001$), perfectionistic strivings (β = -0.110, SE = 0.037, $p < 0.05$), and perfectionistic concerns (β = 0.117, SE = 0.041, $p < 0.05$). For professional efficacy, significant variables included only meaningfulness (β = 0.154, SE = 0.029, $p < 0.001$) and neuroticism (β = -0.155, SE = 0.031, $p < 0.001$). Finally, variables associated with engagement included work-home conflict (β = -0.195, SE = 0.040, $p < 0.001$), emotional demands (β = 0.084, SE = 0.032, $p < 0.05$), meaningfulness (β = 0.251, SE = 0.032, $p < 0.001$), learning opportunities (β = 0.111, SE = 0.031, $p < 0.001$), support from peers (β = 0.080, SE = 0.033, $p < 0.05$), neuroticism (β = -0.247, SE = 0.034, $p < 0.001$) and perfectionistic strivings (β = 0.119, SE = 0.032, $p < 0.001$). Contrary to expectations, emotional demands showed a small but significant positive association with engagement. This effect only showed when work–home conflict or role conflict were included in the model. However, interaction effects between emotional demands and work–home conflict ($p = 0.688$) as well as role conflict ($p = 0.08$) were not statistically significant. Table 1 shows the LMM results for each outcome variable.

Discussion

The results show that emotional exhaustion and cynicism modestly but gradually increased over residency years, while engagement slightly declined and professional efficacy remained stable. Among the demands examined, work–home conflict showed the strongest association with the outcome variables, whereas meaningfulness was identified as the most prominent resource. As anticipated, neuroticism was the strongest personal factor consistently linked to all outcome variables. Although several additional variables reached statistical significance, most effects were relatively modest and should therefore be interpreted with caution.

Increasing emotional exhaustion and cynicism, and decreasing engagement

Hypothesis 1 was partially supported, with modest but significant increases in emotional exhaustion as well as cynicism, and decreases in engagement observed across residency years. These findings align with former studies indicating a progressive rise in burnout dimensions accompanied by a declining trend in engagement during medical education [5–7, 11]. This trend raises concerns about the loss of motivation and energy as residents advance, reflecting prolonged exposure to high demands without sufficient resources [26]. Notably, professional efficacy remained stable across all residency years. This suggests that, while residents may feel emotionally exhausted and more detached from work over the years, their perceived professional efficacy remains intact. Overall, this pattern may indicate that burnout dimensions do not change uniformly and that professional efficacy may follow a distinct trajectory from emotional exhaustion and cynicism. This aligns with prior research suggesting that professional efficacy may function either as a precursor to or a consequence of these dimensions, and may be more closely linked to engagement than the other two other dimensions [57–62].

The importance of a healthy work-home balance and meaningful work

Hypothesis 2 was supported by our results. Among the work-related variables, work-home conflict was identified as the strongest and most consistent demand for all outcomes. It showed the largest effect size for emotional exhaustion and was also significantly associated with cynicism and engagement. This is consistent with previous studies highlighting the importance of a healthy work–home balance for burnout and work engagement [32, 63–68]. To understand the importance of a healthy work-home balance, it should be situated in the broader societal context, including evolving gender roles and the erosion of work-home boundaries, amplified in part by technological advancements [64, 69–72]. As both women and men now increasingly engage in both earning and caregiving roles, the functional separation between work and home domains becomes less clear, intensifying the potential for increasing burnout complaints [70, 73]. Digital technologies, despite enabling flexibility, also stimulate constant connectivity, increasing stress and complicating efforts to maintain healthy work–life boundaries [69, 74]. Notably, earlier studies have proposed more complex roles for work–home conflict (e.g., as a mediator or moderator within broader models) and suggested reciprocal associations with burnout and engagement over time [37, 75–77]; however, these remain to be further investigated as they were not examined in the present study. Role conflict, staffing inadequacies,

Table 1 LMM Results of significant variables of the outcome variables

Variables	Emotional exhaustion			Cynicism			Professional Efficacy			Engagement		
	B (SE)	CI (95%)		B (SE)	CI (95%)		B (SE)	CI (95%)		B (SE)	CI (95%)	
		Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
(Intercept)	**3.342 (0.164)*****	3.022	3.661	**2.433 (0.211)*****	2.023	2.843	**4.750 (0.164)*****	4.431	5.068	**4.677 (0.181)*****	4.325	5.029
Gender (female)	-0.062 (0.062)	-0.181	0.058	**-0.578 (0.081)*****	-0.734	-0.421	-0.036 (0.061)	-0.155	0.084	-0.075 (0.067)	-0.205	0.054
Residency year	-0.016 (0.018)	-0.051	0.018	-0.005 (0.023)	-0.050	0.039	0.027 (0.018)	-0.008	0.062	**-0.063 (0.020)*****	-0.102	-0.024
Specialism (other)	**-0.299 (0.073)*****	-0.440	-0.157	0.018 (0.095)	-0.166	0.203	**-0.207 (0.072)***	-0.348	-0.067	0.170 (0.079)	0.016	0.323
Cognitive demands	-0.038 (0.028)	-0.093	0.017	-0.055 (0.036)	-0.125	0.016	0.011 (0.030)	-0.047	0.070	0.038 (0.031)	-0.022	0.098
Workload	**0.110 (0.031)*****	0.050	0.169	-0.031 (0.039)	-0.106	0.045	-0.071 (0.036)	-0.141	-0.002	0.009 (0.033)	-0.057	0.074
Work-Home conflict	**0.537 (0.036)*****	0.467	0.608	**0.292 (0.046)*****	0.203	0.382	0.066 (0.028)	0.011	0.121	**-0.195 (0.040)*****	-0.272	-0.117
Emotional demands	**0.152 (0.029)*****	0.095	0.208	**0.087 (0.037)***	0.015	0.159	0.008 (0.031)	-0.052	0.067	**0.084 (0.032)***	0.022	0.145
Staffing	0.046 (0.031)	-0.014	0.106	**0.173 (0.039)*****	0.096	0.249	-0.030 (0.030)	-0.088	0.029	-0.002 (0.034)	-0.068	0.064
Role conflict	**0.152 (0.031)*****	0.091	0.213	**0.120 (0.040)***	0.043	0.198	0.034 (0.027)	-0.020	0.087	-0.056 (0.034)	-0.123	0.011
Meaningfulness	**-0.103 (0.029)*****	-0.160	-0.046	**-0.123 (0.037)*****	-0.196	-0.051	**0.154 (0.029)*****	0.098	0.210	**0.251 (0.032)*****	0.189	0.314
Learning opportunities	-0.039 (0.029)	-0.095	0.017	-0.018 (0.036)	-0.088	0.053	0.041 (0.028)	-0.013	0.095	**0.111 (0.031)*****	0.050	0.172
Learning environment	-0.008 (0.028)	-0.064	0.047	-0.001 (0.036)	-0.071	0.069	0.005 (0.027)	-0.049	0.058	-0.008 (0.031)	-0.068	0.053
Support peers	-0.048 (0.030)	-0.106	0.011	-0.066 (0.038)	-0.141	0.008	0.061 (0.029)	0.005	0.118	**0.080 (0.033)***	0.016	0.143
Support supervisor	0.014 (0.033)	-0.051	0.079	0.027 (0.042)	-0.055	0.109	0.036 (0.032)	-0.027	0.098	0.080 (0.036)	0.010	0.151
Control over working time	-0.040 (0.030)	-0.099	0.019	0.040 (0.039)	-0.036	0.115	-0.038 (0.030)	-0.096	0.020	-0.001 (0.033)	-0.065	0.064
Neuroticism	**0.355 (0.032)*****	0.293	0.417	**0.191 (0.041)*****	0.111	0.271	**-0.155 (0.031)*****	-0.216	-0.094	**-0.247 (0.034)*****	-0.314	-0.179
Perfectionistic strivings	-0.022 (0.029)	-0.079	0.034	**-0.110 (0.037)***	-0.183	-0.037	0.019 (0.029)	-0.037	0.074	**0.119 (0.032)*****	0.058	0.181
Perfectionistic concerns	0.040 (0.032)	-0.023	0.103	**0.117 (0.041)***	0.036	0.198	-0.054 (0.032)	-0.115	0.008	-0.041 (0.035)	-0.109	0.028
ICC	0.4905			0.617			0.651			0.598		
Observations	971			971			971			969		
Log Likelihood	-1051			-1291			-1034			-1132		
AIC	2149			2629			2114			2311		
BIC	2261			2741			2226			2423		

B Beta Coefficient, *SE* Standard Error, *CI* Confidence Interval

*$p < 0.05$; **$p < 0.01$,***$p < 0.001$, Benjamini-Hochberg correction for multiple comparisons

workload, and emotional demands were also associated with increased emotional exhaustion and cynicism, though with smaller effect sizes. These associations are consistent with existing literature [67, 68, 78–84]. Notably, emotional demands showed a small yet statistically significant positive association with work engagement. This positive association with engagement was observed after adding work-home conflict and/or role conflict to the model, however, interaction effects were not significant. Considering the small effect size and borderline significance, this finding should be interpreted with caution. Meaningfulness was an important resource across all outcomes. It was negatively associated with emotional exhaustion and cynicism, while showing positive associations with professional efficacy and work engagement. These results suggest that perceiving one's work as meaningful may protect against burnout and promote engagement, which was confirmed by former studies [38, 85, 86]. Additionally, engagement was overall linked to three job resources (i.e. meaningfulness, learning opportunities, and peer support) and only one demand (i.e. work-home conflict), highlighting the importance of resources for engagement, which is in line with former studies [87, 88].

Personality traits

Neuroticism was a strong and consistent personality-related variable across all outcomes. It was positively associated with emotional exhaustion and cynicism, and negatively related to professional efficacy and work engagement. These findings reinforce its role as a vulnerability factor for burnout, as shown in previous research [33, 34, 89]. For instance, Bianchi et al. (2021) reported neuroticism to be more influential than work-related or social factors. As for perfectionism, perfectionistic strivings showed a small but significant positive effect on work engagement and a negative association with cynicism. This suggests that this dimension may serve as a motivational resource, protecting against burnout [36, 90]. In contrast, perfectionistic concerns were weakly but positively related to cynicism, indicating potential vulnerability. However, due to insufficient statistical power, we were not able to examine potential mediating or moderating effects of these personality traits. Therefore, caution is necessary interpreting the direct influence of personality traits, as mediation analyses in other studies suggest a more complex relationship in which personality also shapes demands and resources that subsequently affect burnout and/or engagement [91].

Strengths and limitations

A key strength of this study is the large dataset, covering six years of medical residency training over four measurement points, allowing us to track changes in burnout dimensions and engagement across residency years. Another strength is the study's focus on a broad range of variables including demands, resources, and personality traits, providing a nuanced understanding of their associations with burnout dimensions and engagement. Further, the diverse sample, including GP and other residents from five medical faculties in Flanders, enhances the generalizability of our findings. However, several limitations should also be acknowledged. First, voluntary participation may have introduced self-selection bias, as residents with personal interest in or experiences with burnout may have been more likely to participate. For example, attrition t-tests showed slightly higher emotional exhaustion scores among participants who responded more than twice compared to those who responded only once. Additionally, despite sustained recruitment efforts, the sample size within each residency year remained relatively modest, particularly in the sixth year, which limits representativeness and statistical power. This limitation is partly attributable to the structural challenge of engaging residents, a hard-to-reach population due to their demanding responsibilities. Further, reliance on self-report instruments such as the MBI and COPSOQ may have introduced bias due to social desirability or inaccuracies in recall. In the same context, assessing supervisor support in medical residency should be done with caution, as it may be unclear to residents who qualifies as their supervisor, potentially introducing ambiguity in this measure. Moreover, our analyses do not assess or diagnose clinical burnout, but rather examine burnout dimensions as continuous psychological constructs. Nevertheless, these instruments are widely validated and remain standard tools in occupational health research on burnout and work-related psychosocial factors. Finally, cohort bias should be considered, as differences observed between residency years could also be attributed to cohort-specific characteristics.

Conclusion

This study provides a comprehensive, multi-year overview of burnout and engagement across medical residency and identifies key work and personal factors associated with these outcomes. Our findings show a consistent but modest pattern of increasing emotional exhaustion and cynicism, alongside declining engagement, while professional efficacy remains stable across training years. Within the broader framework, work–home conflict was identified as the most relevant job demand, and meaningfulness as the most important resource, highlighting their key role in residents' well-being. In addition, neuroticism stood out as a consistent personal factor across all outcomes. Together, these results underscore that burnout dimensions in residency are influenced by a combination of demands, resources,

and individual vulnerability, rather than by any single factor.

Abbreviations

BFI-XS	Big Five Inventory-Extra Short
COPSOQ	Copenhagen Psychosocial Questionnaire
FIML	Full Information Maximum Likelihood
FMPS	Frost Multidimensional Perfectionism Scale
GP	General Practice
JD-R	Job Demands – Resources
LMM	Linear Mixed-effects Models
M	Mean
MAR	Missing At Random
MCAR	Missing Completely At Random
SD	Standard Deviation
UBOS-C	Utrecht Burnout Scale – Contact-based professions
UWES	Utrecht Work Engagement Scale

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-026-09568-y.

Supplementary Material 1

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Authors' contributions

A.B., J.S., O.L., L.B., N.M., D.D., A.R., H.K., M.C.L, S.V. and L.G. all meet the ICMJE criteria. A.B., S.V., and L.G. conceptualised the design and implementation of the data collection and developed the content of the questionnaire. A.B., L.B., N.M., D.D., A.R., H.K., O.L. and L.G. have contributed significantly to the recruitment of the participants. A.B., J.S. and L.G. conducted the statistical analyses, and all authors were part of the interdisciplinary research team that discussed findings. Finally all authors contributed to the writing of the article and approved the final submitted version.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The WeMeds study was approved by the Ethics Committee Research UZ/KU Leuven in April 2021 (S64150). All participants provided signed informed consent for participation. Consent for publication was not applicable to this study, and a clinical trial registration number was not required. The study was conducted in accordance with the ethical principles for medical research involving human subjects as outlined in the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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