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Human-technology interaction at work: the moderating role of work modality in the relationship between colleague support and technostress

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Introduction: The increasing digitalization of work and the diffusion of hybrid work arrangements are reshaping human–technology interaction, with relevant implications for job quality and occupational health. Within this context, technostress represents a salient psychosocial risk emerging from the interaction between technological demands and work design features. Drawing on the Job Demands–Resources framework, this study focuses on colleague support as a key social resource that may shape employees' experiences of technostress in digitally mediated work.

Materials and methods: Using a cross-sectional design, moderated regression analyses were conducted on a sample of 316 employees working in hybrid and on-site arrangements. Participants completed validated measures of technostress creators (techno-complexity, techno-invasion, and techno-overload) and perceived colleague support and reported their work modality.

Results: Results indicate that perceived colleague support is consistently and negatively associated with overall technostress and all technostress creators, supporting its role as a key social resource for employee wellbeing. Furthermore, moderation analyses revealed that work modality shapes the relationship between colleague support and technostress. However, the protective association between colleague support and technostress and its dimensions was evident only among hybrid workers and not in fully on-site settings. These findings suggest that in hybrid contexts, where opportunities for interaction are more limited, colleague support is perceived as a more valuable resource. In contrast, in fully on-site environments, the constant availability of interpersonal exchange may lead to its normalization, thereby reducing its perceived value as a distinct coping resource.

Conclusions: The findings highlight the importance of conceptualizing human–technology interaction as a workplace issue embedded in social and organizational contexts. From an occupational safety and health perspective, the study underscores the role of colleague support as a protective resource that can

buffer technostress in digitally mediated and flexible work settings. Investing in social infrastructures that foster collegial support appears crucial for promoting employee wellbeing and sustainable work in digitalized environments.

KEYWORDS

colleague support, human-technology interaction, ICT at work, organizational psychology, social ergonomics, technostress

1 Introduction

Over the last decade, and particularly following the acceleration induced by the COVID-19 pandemic, work arrangements have undergone profound transformations. Traditional on-site work has increasingly been complemented, and in some instances supplanted, by remote and hybrid modalities, reshaping how employees interact, collaborate, and perform their tasks. These changes have implied an intensified use of Information and Communication Technologies (ICTs), which are increasingly embedded in everyday work practices and organizations.

While ICTs enable flexibility, efficiency, and continuity of work across physical boundaries, their extensive and often continuous use also introduces new psychological challenges. Flexible work arrangements can facilitate work–life balance and sustainable work practices; however, they may also elevate fatigue levels and the likelihood of work–life conflict (Bellini et al., 2025).

In hybrid and remote contexts, employees are increasingly required to adopt digital platforms, manage constant connectivity, and adapt to evolving technological demands. As a result, the digitalization of work has emerged as a critical domain for occupational health research, particularly in terms of its implications for employee wellbeing and stress experiences.

Within this evolving work scenario, the concept of technostress has gained increasing scholarly attention. Technostress (Brod, 1984) refers to a form of stress experienced by individuals due to their inability to cope with the demands associated with the use of ICTs at work. Prior literature has conceptualized technostress as a multidimensional construct, often operationalized through specific technostress creators or primary technological stressors (Ragu-Nathan et al., 2008; Tarafdar et al., 2007; Tams et al. 2015). These stressors are particularly salient in flexible work arrangements, where digital tools serve as the primary medium for task execution and social interaction.

In parallel with research on technological demands, scholars have increasingly emphasized the importance of empowering job resources able to mitigate this specific employees' experiences of stress. In the framework of the Job Demands-Resources (JD-R) model, colleague support represents a fundamental social resource, especially in technology-intensive work settings, where colleagues can facilitate knowledge sharing, provide informal guidance in the use of ICTs, and contribute to a sense of social connectedness (Galanti et al., 2024). Prior research suggests that higher perceived colleague support tends to be associated with lower levels of work-related stress (Chênevert et al., 2019; Wolgast and Fischer, 2023).

However, although research has extensively examined technostress and social support, limited attention has been paid to work modality as a system-level condition shaping both exposure to techno-demands and the effectiveness of social resources. It remains unclear whether colleague support operates differently across on-site and hybrid work arrangements. Hybrid work arrangements, which combine on-site and remote work, may introduce unique challenges compared to full on-site work, as they imply distinct configurations of work organization and coordination. For instance, hybrid workers often rely more heavily on digital communication tools, experience reduced opportunities for informal interactions, and face greater complexity in coordinating tasks and expectations across settings. In particular, while colleague support is widely recognized as a protective factor, its buffering role may vary depending on the degree to which work interactions are mediated by technology. Therefore, understanding whether the association between colleague support and technostress differs between on-site and hybrid workers represents a relevant gap in the current literature.

In light of these considerations, the present study aims to examine the relationships between perceived colleague support, work modality, and technostress creators in contemporary digitalized work environments. By adopting a system-level perspective grounded in the JD-R framework, this study moves beyond examining technostress as an individual-level phenomenon and instead treats work modality as a structural condition that shapes both the configuration of technological demands and the effectiveness of available social resources.

The study seeks to: (a) investigate the association between colleague support and technostress creators; (b) examine whether work modality is associated with different configurations of technostress creators compared to full on-site work; and (c) explore whether work modality moderates the relationship between colleague support and technostress, such that the protective function of social resources may be amplified or attenuated depending on the degree of technological mediation characterizing the work context.

In doing so, this study contributes to the growing body of research on occupational wellbeing in digitalized and flexible work settings, offering theoretical and practical insights for organizations seeking to design work systems that are both technologically efficient and psychologically sustainable.

2 Literature review

2.1 The Job Demands–Resources Model (JD-R Model) and technostress: theoretical application of the model

The Job Demands–Resources (JD-R) model represents one of the most well-established theoretical frameworks in occupational health psychology for explaining how job characteristics influence employees' psychological wellbeing, stress, and health-related outcomes (Bakker and Demerouti, 2007, 2017). The model posits that work characteristics can be broadly classified into job demands—physical, cognitive, or emotional aspects of work that require sustained effort—and job resources—structural or social aspects that support goal achievement and personal growth. The application of the JD-R model to digitalized work contexts has led to the conceptualization of ICTs as a specific source of job demands. Technostress creators—including techno-complexity, techno-overload, and techno-invasion—can be understood as technology-specific job demands (Tarafdar et al., 2007; Ragu-Nathan et al., 2008), stemming from the increasing complexity of technologies, information overload, and the intrusion of technology-mediated work into the private sphere, requiring workers to engage in continuous cognitive and emotional adaptation (Tarafdar et al., 2019).

From a JD-R perspective, technostress creators activate the health impairment process when they are not adequately offset by job resources (Ragu-Nathan et al., 2008; Califf et al., 2020). Empirical studies conducted in digitalized organizational contexts show that intensive ICT use is associated with higher levels of perceived stress, fatigue, and reduced psychological wellbeing, particularly when technological demands exceed available resources (Pirkkalainen et al., 2019; Molino et al., 2020b,a).

The application of the JD-R model to remote and hybrid work has further highlighted how work digitalization may amplify job demands, increasing exposure to both technological and psychosocial stressors (Ipsen et al., 2021). In these contexts, drawing on sociotechnical system theory, technology may be conceptualized not merely as an operational tool but as a structural component of the work system (Spreitzer et al., 2017), though the present study did not directly measure these organizational-level dynamics.

At the same time, the JD-R model allows for the identification of specific techno-resources—job resources that support employees in managing technological demands—including organizational support, training, autonomy, and social support, which has proven to be particularly relevant in mitigating the negative effects of technostress (Salanova et al., 2013; Gaudioso et al., 2017). When adequate resources are available, the impact of technostress creators on strain-related outcomes is attenuated, thus supporting the validity of the JD-R model in explaining technostress as an emergent outcome of digitally designed work systems (Bakker and Demerouti, 2017).

2.2 Social support and its inhibitory effect on technostress: evidence from the literature

Within the JD-R model, social support is widely recognized as a core job resource for safeguarding psychological wellbeing and reducing occupational stress (Bakker and Demerouti, 2007; Schaufeli and Taris, 2014). Social support encompasses both instrumental and emotional assistance provided by colleagues, supervisors, and the organization, and it is consistently associated with lower levels of strain and burnout (Van den Broeck et al., 2016).

In high-technology work contexts, social support plays a particularly critical role, as it facilitates adaptation to technological changes and reduces the psychological burden associated with digital demands (Pirkkalainen et al., 2019; Tarafdar et al., 2019). A growing body of research shows that employees who perceive higher levels of social support report lower levels of technostress and its psychological outcomes, including anxiety, fatigue, and reduced job satisfaction (Salanova et al., 2013; Califf et al., 2020).

Among the different sources of social support, colleagues' support emerges as especially relevant in digitally mediated work settings. Peer-support relationships foster informal learning, knowledge sharing, and collective problem-solving, all of which are essential for coping with complex and continuously evolving technologies (Noe et al., 2014; Leonardi, 2014). Empirical evidence indicates that colleagues' support is negatively associated with key technostress creators, particularly techno-complexity, by reducing the cognitive effort required to use technology (Gaudioso et al., 2017; Califf et al., 2020). Colleague support deserves particular attention in contemporary digitalized work environments because, unlike supervisor support (which operates within formal hierarchical structures and may be perceived as evaluative) or organizational support (which is more abstract), it is characterized by peer-level reciprocity and informal cooperation. Accordingly, research shows that co-worker support has unique effects on work-related stress outcomes and operates as both a direct mitigating factor and a moderator in stressor-wellbeing relationships (Wolgast and Fischer, 2023; Loera et al., 2013). This focus is further justified by the specific aims of the present study. Because colleague support is the social resource most directly shaped by physical co-presence, its accessibility is expected to vary systematically across work modalities—being more constrained in hybrid arrangements, where opportunities for spontaneous peer interaction depend on the alternation between remote and in-person days.

Moreover, colleague support may help reduce strain associated with techno-overload and techno-invasion by facilitating task coordination and the shared management of work-life boundaries in digitally mediated contexts (Derks and Bakker, 2014).

Social support has also been examined as a buffering factor in the relationship between job demands and technostress. JD-R–based studies suggest that the protective effect of social support is particularly pronounced under conditions of high demands, such as those typical of digitalized work environments and remote work settings (Salanova et al., 2013). In these situations, reduced face-to-face interactions and increased reliance on ICTs may amplify

technostress creators, making social support a crucial resource for maintaining psychological wellbeing (Charalampous et al., 2019).

However, the literature also highlights that the effectiveness of social support in reducing technostress is not uniform across work contexts. Differences in work design, organizational climate, and work organization modalities may influence both the accessibility and the actual usability of social support (Spreitzer et al., 2017). These findings suggest that social support should be considered not only as an individual resource but also as a systemic characteristic of digitally designed workplaces, reinforcing the need to conceptualize human–technology interaction as an organizational system-level issue (Tarafdar et al., 2019). This variability in the effectiveness of social support across contexts directly motivates the examination of work modality as a potential moderator of the relationship between colleague support and technostress.

2.3 The impact of work modality on technostress: comparing on-site, hybrid, and remote work in terms of exposure to stressors

Work modality (e.g., remote, hybrid, or on-site) is conceptualized as a system-level work design characteristic rather than an individual-level variable. Drawing on sociotechnical systems theory (Trist and Bamforth, 1951), work modality reflects the interdependence between the technological subsystem (e.g., digital tools, communication platforms, and IT infrastructure) and the social subsystem (e.g., team structures, organizational norms, work arrangements). According to this perspective, work modality is not merely an individual preference or choice but a structural feature that emerges from the co-optimization of technology and organizational practices. This theoretical framing helps explain how work modality shapes both technology use and social dynamics (e.g., colleague support, supervisor interactions) at the organizational level, making it a critical system-level determinant of technostress and employee wellbeing.

Within the Job Demands–Resources (JD-R) framework, work modality can be conceptualized as a system-level work design characteristic capable of simultaneously reshaping the configuration of job demands and job resources, rather than as a mere contextual variable (Bakker and Demerouti, 2007; Korunka and Vartiainen, 2017). Work modality represents a work design characteristic capable of modulating both the intensity of techno-demands and the accessibility of social resources, so that the same level of perceived colleague support may carry different protective value depending on the structural affordances available in each work configuration. From this perspective, different work modalities shape how human–technology interaction is enacted within organizational systems, influencing both exposure to technological stressors and access to protective resources relevant to occupational safety and health (OSH).

The technostress literature identifies technostress creators—particularly techno-overload, techno-invasion, and techno-complexity—as key technology-related job demands in digitally mediated work contexts (Tarafdar et al., 2007; Ragu-Nathan et al., 2008; Tarafdar et al., 2019). These dimensions reflect, respectively, the intensification of information load, the permeability of work–life boundaries, and the cognitive effort required to learn and use technologies perceived as complex. From a JD-R perspective, such technological demands may activate the health impairment process when they are not adequately balanced by job resources.

In fully remote work contexts, digital technologies constitute the primary channel through which work tasks are coordinated, monitored, and performed. This centrality of ICTs tends to increase exposure to techno-overload and techno-invasion due to continuous connectivity, incessant information flows, and extended availability expectations (Derks and Bakker, 2014; Tarafdar et al., 2007, 2019). Empirical evidence further indicates that remote work is frequently associated with reduced spontaneous social interactions and increased feelings of isolation, conditions that may amplify the psychological impact of technological demands (Ipsen et al., 2021). From an occupational health perspective, remote work can therefore be interpreted as a system configuration in which techno-demands are particularly salient, while informal access to social resources is structurally constrained (Charalampous et al., 2019).

Hybrid work can be understood as an intermediate configuration of the work system, combining high exposure to digital technologies with intermittent access to face-to-face interactions. Although techno-demands remain central due to the continued reliance on ICTs, the in-person component of hybrid work may partially restore access to relevant social resources, such as informal support and immediate feedback (Gajendran and Harrison, 2007).

However, this restoration is structurally incomplete: the alternation between remote and in-person days limits the spontaneity and predictability of peer interactions, making perceived colleague support—rather than incidentally occurring support—the more functionally relevant resource for managing technological demands (Gibbs et al., 2021). In JD-R terms, this configuration suggests a more dynamic balance between demands and resources; however, the literature highlights substantial heterogeneity in hybrid work arrangements, warranting caution in generalizing differential effects on technostress (Gibbs et al., 2021).

By contrast, in fully on-site work contexts, the structural availability of face-to-face communication and non-mediated coordination may reduce exclusive reliance on ICTs as the primary means of work regulation. Although digital tools remain integral to work processes, in-person interaction tends to reinforce temporal and spatial work boundaries, thereby reducing techno-invasion, and facilitates immediate access to clarification and peer support, helping to contain techno-complexity (Korunka and Vartiainen, 2017; Salanova et al., 2007). In such configurations, support is more structurally embedded in the daily work environment, which may reduce its salience as a consciously perceived resource and consequently attenuate its marginal protective effect on technostress (Charalampous et al., 2019). From this perspective, on-site work can be viewed as a system configuration in which technological demands are embedded within a broader and more accessible social infrastructure.

Overall, these considerations suggest that work modality should be interpreted not so much as a direct predictor of technostress,

but rather as a systemic condition that modulates the intensity, salience, and consequences of techno-demands in digitally designed workplaces. This approach is consistent with a view of human–technology interaction as an emergent property of work systems, in which technological adoption, social relationships, and work design jointly shape exposure to psychosocial risks and occupational health outcomes (Spreitzer et al., 2017).

Building on this argument, the following section derives three testable hypotheses regarding the independent and joint effects of colleague support and work modality on technostress.

2.4 Research hypotheses

The theoretical and empirical arguments developed in the preceding sections converge on three testable propositions. First, drawing on the JD-R model and the established literature on social resources in digitalized work contexts, colleague support is expected to function as a protective resource against technology-specific job demands. Second, given the differential configurations of ICT reliance and social resource accessibility across work modalities, hybrid and on-site work are expected to differ in employees' exposure to technostress creators. Third, and most critically, if the effectiveness of social resources depends on the structural context in which they operate—as the JD-R buffering hypothesis and the hybrid work literature jointly suggest — then work modality should moderate the relationship between colleague support and technostress, with the protective effect being more pronounced precisely where structural supportive affordances are weakest. Based on the preceding arguments, we propose the following hypotheses:

H1. Perceived colleague support is negatively associated with technostress creators, meaning that employees who perceive higher levels of support from their colleagues tend to experience lower levels of technostress.

H2. Hybrid work modality is expected to be associated with distinct levels of technostress creators compared to on-site work. Specifically, hybrid workers are expected to report higher levels of technostress creators compared to on-site workers. Given their greater reliance on ICTs as the primary medium for task coordination and communication, and their more limited access to spontaneous face-to-face interactions, hybrid workers are theoretically exposed to a more demanding techno-environment. From a JD-R perspective, this configuration implies heightened techno-demands (e.g., greater techno-overload and techno-invasion due to continuous connectivity) with comparatively reduced informal access to social resources, thereby increasing vulnerability to technostress creators (Tarafdar et al., 2007; Charalampous et al., 2019).

H3. Work modality moderates the relationship between colleague support and technostress, such that the negative association is stronger for hybrid workers.

Figure 1 illustrates the conceptual model summarizing these hypothesized relationships.

3 Methods

This study employed a cross-sectional survey design to examine the relationships between colleague support, work modality, and technostress creators among employees working in hybrid and fully on-site arrangements.

After identifying the most appropriate scales in line with the literature and research objectives, a structured procedure was undertaken to develop and administer the questionnaire. The initial step consisted of translating and linguistically adapting several of the selected scales. Subsequently, the overall design and layout of the questionnaire were defined and finalized. This was followed by the recruitment of Italian companies and professional organizations from both the public and private sectors, representing various industries, organizational sizes, and work arrangements (on-site, hybrid, and remote). Organizations were included based on their willingness to participate and the presence of work practices that incorporated, at least partially, digital technologies for communication and coordination. Contact was primarily initiated via email, which provided a brief overview of the study along with a link to the online questionnaire hosted on the Qualtrics platform. Data collection was conducted throughout April 2025.

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of Cagliari (Research ID: 0262499, approved on 19 September 2024).

3.1 Participants

To estimate the required sample size to test the formulated hypotheses, we conducted an a-priori power analysis using G*Power (Faul et al., 2007). We adopted a conservative effect size ($f^2 = 0.035$; Cohen, 1988, 1994) and a target power of $1–\beta = 0.80$. A small effect size was assumed because participants completed the survey online, and the sample is non-probabilistic. To verify our main hypotheses, we conducted a regression analysis considering 3 total predictors (the two main-effects and the interaction term). Results of power analysis indicated a minimum required sample size of 315 participants. To consider also the impact of non-completers, we gathered a total of $N = 402$ participants, of which 325 completed the questionnaire. Among the excluded participants, $n = 77$ participants abandoned the survey or did not provide informed consent. The gender distribution was well balanced ($n = 159$ women, $n = 161$ men, $n = 5$ other), with a mean age of $M = 42.70$, SD = 11.1. Men were slightly older on average ($M = 44.1$, SD = 11.3) than women ($M = 41.7$, SD = 10.7).

Other sociodemographic variables were explored: concerning educational attainment, the majority of participants held a high school diploma (48.0%), while 48.6% had completed a university degree or higher, indicating a relatively well-educated sample. Regarding the occupational sectors of research participants, the most represented were Banking (21.8%), Electronic/Electromechanical (16%), and Information Technology (15.7%), whereas medium-represented sectors included Construction, Consulting, and Training. Role

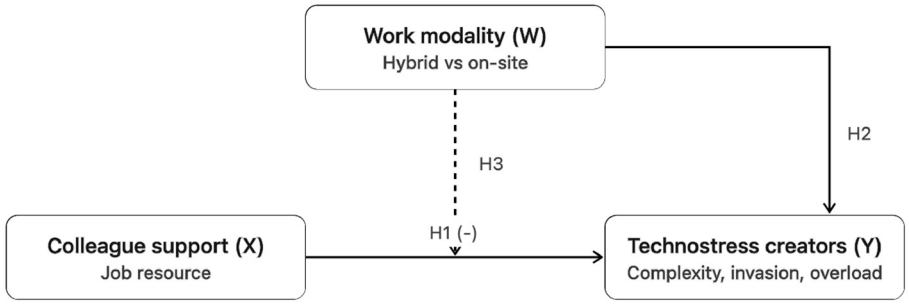

FIGURE 1
Conceptual model of the hypothesized relationships. Given the cross-sectional design, arrows do not imply causal or temporal precedence.

distribution was also diverse, including employees (48.9%), managers (14.5%), executives (6.5%), consultants (12.6%), and workers (12.0%). Regarding work modality, the sample was distributed as follows: 60% fully on-site, 37.2% hybrid, and 2.8% fully remote. Unfortunately, the subgroup of participants working fully remotely was substantially underrepresented ($n = 9$), compared with the hybrid ($n = 121$) and fully on-site groups ($n = 195$). Due to this disproportionate distribution, the fully remote subgroup was not included in the analyses, resulting in a final analytic sample of 316 participants.

3.2 Measures

Two well-establishedscales, previously applied in organizational settings, were used to measure the constructs of interest: *Technostress Creators Scale* (Molino et al., 2020b,a), used to assess workers' perceived levels of technostress in the workplace and *Perceived Coworker Support Scale* (Ladd and Henry, 2000), used to measure the extent to which employees perceive their coworkers as providing both instrumental and emotional support.

3.2.1 Technostress creators

To assess technostress creators, we used the Italian version of the Technostress Creators Scale (Molino et al., 2020b,a), which includes 11 items adapted from the original scale (Ragu-Nathan et al., 2008; Tarafdar et al., 2019). The scale evaluates three dimensions: techno-overload (4 items; e.g., *"I am forced by technology to do more work than I can handle"*), techno-invasion (3 items; e.g., *" I spend less time with my family due to technology "*), and techno-complexity (4 items; e.g., *"I need a long time to understand and use new technologies "*). Responses were recorded on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The scale demonstrated high internal consistency, with a Cronbach's α of 0.87.

3.2.2 Perceived colleague support

To assess perceived colleague support, we employed the Perceived Coworker Support Scale developed by Ladd and Henry (2000), which includes 9 items and captures employees' beliefs regarding the extent to which coworkers provide both instrumental and emotional assistance (Ng and Sorensen, 2008). Example items include *"My co-workers are willing to listen to my personal problems"* and *"My co-workers help me carry out my work activities."* Responses were collected on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree), with higher scores reflecting greater perceived support. The scale demonstrated excellent internal consistency in the present study (Cronbach's $\alpha = 0.90$).

3.2.3 Socio-demographic variables

Alongside the variables directly linked to the research hypotheses, the questionnaire included a set of socio-demographic items to contextualize participants' responses. These items covered general characteristics (e.g., gender, age, and educational attainment) as well as professional information (such as organizational sector and job role). Additionally, the questionnaire assessed participants' work modality to examine whether this factor was associated with differences in their experiences or responses in terms of technostress.

3.3 Data analysis

Data were analyzed using *Jamovi* (version 2.7.6; The jamovi project, 2025). Linear models were estimated with the *GAMLj* module (version 3.6.3; Gallucci, 2019).

Perceived colleague support and work modality were entered as independent variables, while the three dimensions of the Technostress Creators Scale (techno-overload, techno-invasion, and techno-complexity), served as dependent variables. To test the hypotheses, we ran a series of moderated regression analyses in which work modality was specified as the moderator of the association between perceived colleague support and

TABLE 1 Linear regression models with the technostress creators as dependent variables.

Independent variables	Technostress		Techno-complexity		Techno-invasion		Techno-overload	
	β	p	β	p	β	p	β	p
Colleague support	−0.217	< 0.001	−0.170	0.005	−0.211	< 0.001	−0.177	0.004
Work modality	−0.003	0.978	0.209	0.067	−0.133	0.241	−0.120	0.294
Colleague support * work modality	0.372	0. 002	0.373	0. 002	0.338	0.053	0.234	0.054
R^2	0.050		0.051		0.048		0.031	
F (3, 312)	5.52		5.63		5.25		3.34	

technostress. Interaction terms were computed after mean-centering the predictor and moderator variables. This approach allowed us to examine whether the strength or direction of the relationship between perceived colleague support and technostress varied across different work modalities. Significant interactions were probed using simple-slope analyses. All tests were two-tailed, and effects with $p < 0.05$ were considered statistically significant.

3.3.1 Discriminant validity and common method bias

To investigate discriminant validity of the Techno-stress factors and of the Perceived Colleague Support factors, we tested a four-factors Confirmatory Factor Model, with three factors defining the Techno-stress factors (Techno-overload, Techno-Invasion, and Techno-Complexity) and the single factor for the Perceived Colleague Support. Fit indices were satisfactory ($\chi 2(160) = 263.28$, $p < 0.01$; RMSEA = 0.049; RMSEA 90% C.I.:0.038;0.059; CFI = 0.959; TLI = 0.951; RSMR = 0.064). We compared the four-factor model fit with that of a one-factor model (all Technostress and Perceived Colleague Support items loading on a single factor). The one-factor model fits data poorly ($\chi 2(166) = 1640.46$, $p < 0.01$; RMSEA = 0.170; RMSEA 90% C.I.:0.162;0.178; CFI = 0.476; TLI = 0.400; RSMR = 0.189) and the difference between the fit of the two models was significant ($\Delta\chi 2(6) = 983.57$, $p < 0.01$). Turning to the impact of Common Method Bias, the Harman single factor test accounted for about 25% (sum of squared loadings = 4.96) of total covariance among all Technostress and Perceived Colleague Support items. However, following Podsakoff et al. (2003), we also tested a Confirmatory Factor model with the Technostress and Perceived Colleague Support factors along with a Common Method Variance Factor with all loading on all items and constrained to be equal. Results indicated that this last model fit was no better than the model without the common method variance factor ($\chi 2(159) = 252.89$, $p < 0.01$; RMSEA = 0.047; RMSEA 90% C.I.:0.035;0.057; CFI = 0.962; TLI = 0.955; RSMR = 0.061) meaning that common method variance did not pose a serious threat to the validity of our results and conclusions.

4 Results

Results for all regression analyses are shown in Table 1.

***H1**: Effect of colleague support on technostress creators*

H1 proposed that perceived colleague support would be negatively associated with technostress and its core dimensions.

The analyses revealed a significant negative association between perceived colleague support and overall technostress, ($\beta = -0.217$, $SE = 0.039$, $p < 0.001$), indicating that employees who perceived higher levels of support from colleagues reported lower levels of technostress.

A consistent pattern emerged for the specific technostress creators. Colleague support was significantly and negatively related to techno-complexity, ($\beta = -0.170$, SE = 0.046, $p = 0.005$). Similarly, colleague support emerged as a significant negative predictor of techno-invasion, ($\beta = -0.211$, $SE = 0.046$, $p < 0.001$). Finally, higher perceived colleague support was associated with lower levels of techno-overload, ($\beta = -0.177$, $SE = 0.045$, $p = 0.004$).

Overall, these findings underscore the protective role of perceived colleague support in mitigating technostress and its core dimensions, thereby confirming Hypothesis 1.

***H2:** Effect of work modality on technostress creators*

H2 proposed that hybrid work modality would be associated with distinct levels of technostress creators compared to on-site work.

Results indicated that work modality (Hybrid = −1 vs. On-site = 1) did not show a significant main effect on overall technostress, ($\beta = -0.003$, $SE = 0.078$, $p = 0.978$). Similarly, no significant differences were observed for techno-invasion ($\beta = -0.133$, $SE = 0.093$, $p = 0.241$) or techno-overload ($\beta = -0.120$, $SE = 0.091$, $p = 0.294$). For techno-complexity, there was a marginal trend suggesting that on-site workers might experience slightly higher levels compared to hybrid workers, ($\beta = 0.209$, $SE = 0.094$, $p = 0.067$), though this effect did not reach statistical significance.

Looking at means, hybrid and on-site workers reported the same averages for overall technostress (Hybrid: $M = 2.59$; $SE = 0.078$; On-site: $M = 2.59$; $SE = 0.078$). However, hybrid workers scored lower ($M = 2.56$, $SE = 0.093$) than on-site workers ($M = 2.67$, $SE = 0.093$) on techno-invasion, on techno-overload (Hybrid: $M = 2.49$; $SE = 0.091$; On-site: $M = 2.58$; $SE = 0.091$) and on techno-complexity (Hybrid: $M = 2.45$; $SE = 0.094$; On-site: $M = 2.62$; $SE = 0.094$).

Overall, these results indicate that work modality alone (hybrid vs. on-site) was not associated with meaningful differences in the experience of technostress or its primary dimensions. In other words, employees working in hybrid arrangements did not

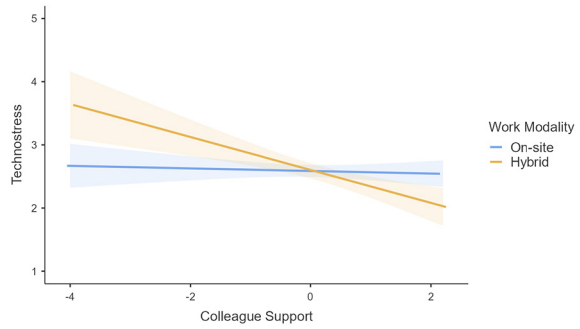

FIGURE 2
The relationship between technostress and colleague support moderated by work modality.

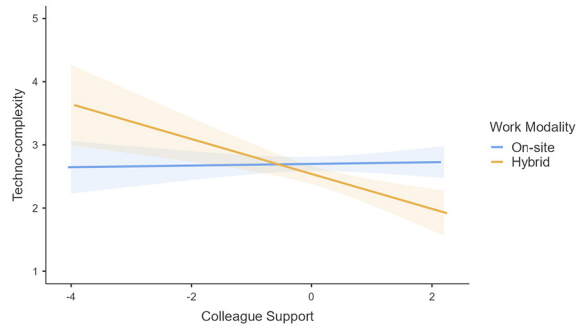

FIGURE 3
The relationship between techno-complexity and colleague support moderated by work modality.

report significantly higher or lower levels of technostress compared to those working entirely on-site. Moreover, contrary to the directional prediction of H2—which expected hybrid workers to report higher technostress due to greater ICT reliance and reduced access to informal social resources—hybrid workers tended to report slightly lower levels of technostress compared to on-site workers, although these differences were not statistically significant. Therefore, Hypothesis 2 was not supported.

H3: *Work modality as a moderator of the relationship between colleague support and technostress*

H3 proposed that work modality moderates the relationship between colleague support and technostress, such that the negative association is stronger for hybrid workers.

A moderated regression analysis was conducted to examine whether work modality moderated the relationship between colleague support and technostress and its specific dimensions. The overall model predicting technostress was significant (Figure 2), $F(3, 312) = 5.52$, $p = 0.001$, explaining 5.0% of the variance ($R^2 = 0.050$). When examining the technostress dimensions separately, the models explained 5.13% of the variance in techno-complexity ($F(3, 312) = 5.63$, $p < 0.001$, $R^2 = 0.051$), 4.81% in techno-invasion ($F(3, 312) = 5.25$, $p = 0.002$, $R^2 = 0.048$), and 3.11% in techno-overload ($F(3, 312) = 3.34$, $p = 0.020$, $R^2 = 0.031$).

With respect to technostress, the interaction between colleague support and work modality was significant, $\beta = 0.372$, $SE = 0.078$, $p = 0.002$, indicating that the relationship between colleague support and technostress varied by work modality. More specifically, subsequent simple slope analyses revealed that the effect of colleague support on the overall technostress was significant only in the hybrid condition, $F(1, 312) = 16.289$, $p < 0.001$, $\beta = -0.261$, $SE = 0.065$, $p < 0.001$, whereas it was not significant in the fully on-site condition, $F(1, 312) = 0.226$, $p = 0.635$, $\beta = -0.020$, $SE = 0.043$, $p = 0.635$. This relationship is illustrated in Figure 2.

A similar pattern emerged for the specific technostress creators. For techno-complexity, the interaction between colleague support and work modality was statistically significant, ($\beta = 0.373$, $SE = 0.093$, $p = 0.002$). Subsequent simple slope analyses showed that the main effect of colleague support on techno-complexity was significant only in the hybrid condition, $F(1, 312) = 12.700$, $p < 0.001$, $\beta = -0.276$, $SE = 0.077$, $p < 0.001$, and not significant in the fully on-site condition, $F(1, 312) = 0.065$, $p = 0.800$, $\beta = 0.013$, $SE = 0.051$, $p = 0.800$, as illustrated in Figure 3.

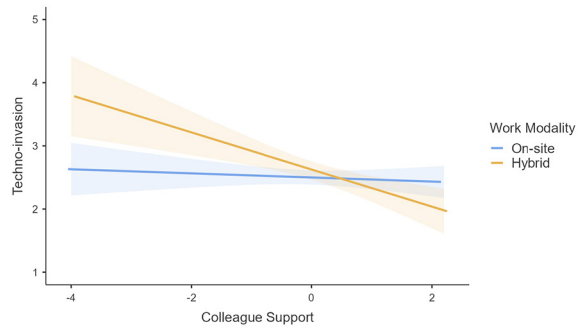

FIGURE 4
The relationship between Techno-invasion and Colleague Support moderated by Work Modality

For techno-invasion, the interaction between colleague support and work modality was also significant, ($\beta = -0.338$, $SE = 0.093$, $p = 0.005$). Additionally, simple slope analyses revealed that the main effect of colleague support was significant only in the hybrid condition, $F(1, 312) = 14.435$, $p < 0.001$, $\beta = -0.294$, SE = 0.077, $p < 0.001$, and not significant in the fully on-site condition, $F(1, 312) = 0.064$, $p = 0.527$, $\beta = -0.032$, $SE = 0.051$, $p = 0.527$, as illustrated in Figure 4

Finally, for techno-overload, ($F(3, 312) = 3.34$, $p = 0.020$, $R^2 = 0.031$, the interaction showed a marginal effect, ($\beta = 0.234$, $SE = 0.091$, $p = 0.054$. However, simple slope analyses indicated that the main effect of colleague support was significant in the hybrid condition, $F(1, 312) = 8.453$, $p = 0.004$, $\beta = -0.220$, $SE = 0.076$, $p = 0.004$, but not significant in the fully on-site condition, $F(1, 312) = 0.791$, $p = 0.375$, $\beta = -0.045$, $SE = 0.050$, $p = 0.375$, as illustrated in Figure 5.

These results suggest that work modality moderates the protective effect of colleague support on technostress and its dimensions. However, the findings indicate that this effect occurs only in the hybrid work condition and not in the fully on-site condition, thus partially supporting Hypothesis 3.

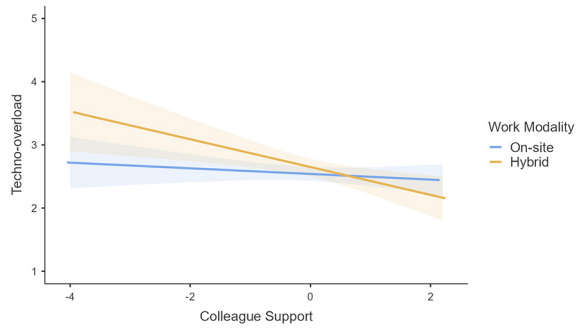

FIGURE 5
The relationship between techno-overload and colleague support moderated by work modality.

5 Discussion

The present study aimed to investigate how colleague support and work modality jointly shape employees' experiences of technostress within digitally mediated work environments. Drawing on the JD-R model, three hypotheses were tested concerning the protective role of social resources, the differential exposure to technostress across work modalities, and the moderating function of hybrid work on the support-technostress relationship. Overall, the findings point to a more nuanced picture: technostress is not simply a product of how much technology one uses, but rather an emergent outcome shaped by the interplay between social resources, organizational structures, and the specific demands of digitally mediated work systems.

Consistent with Hypothesis 1, perceived colleague support was negatively associated with overall technostress as well as with its core dimensions. This finding extends prior work by demonstrating that the buffering function of social support operates not only at a general level but also across specific technostress dimensions –techno-complexity, techno-invasion, and techno-overload—each of which reflects a qualitatively distinct form of technology-induced strain From a JD-R perspective, these results confirm that social resources can offset technology-specific job demands (Bakker and Demerouti, 2007). What is theoretically significant here, however, is the mechanism through which this protection operates. Rather than functioning as a generic coping resource, colleague support appears to work through more targeted pathways: facilitating informal learning and knowledge transfer that reduces the cognitive burden associated with techno-complexity; reinforcing shared communication norms that contain the permeability of work-life boundaries driving techno-invasion: and enabling cooperative task management that distributes the weight of techno-overload. This differentiated pattern of results aligns with recent evidence showing that emotional social support from one's network—including colleagues and supervisors—can mitigate the negative effects of technostress particularly in remote and hybrid work context, where formal support structures are less immediately accessible (Khedhaouria et al., 2024). Similarly, Kakkar et al. (2024) demonstrated that social support positively shapes the teleworker environment and sustains work engagement, suggesting that the relational quality of the work context matters independently of its physical configuration.

Hypothesis 2 was not supported: no statistically significant differences emerged between hybrid and on-site workers in terms of overall technostress or its specific dimensions. Rather than treating this a null result, we argue it carries substantive theoretical implications.

The absence of modality effects challenges the assumption—prevalent in early pandemic-era research—that remote or hybrid work *per se* amplifies technostress through intensified ICT reliance (Galanti et al., 2021). A more parsimonious interpretation is that, in highly digitalized sectors, exposure to techno-demands may be relatively similar across these modalities. Both hybrid and on-site workers frequently rely on ICTs for communication, task coordination, and information management; what differs is consistent with Meier et al. (2023), who found that technostress and digital fatigue in hybrid context are less a function of work location than of how digital tools are integrated into workflow and whether workers have adequate resources to manage them. More broadly, these findings are consistent with a system-level reading of the JD-R framework, which would interpret technostress as an emergent property of digitally designed work systems rather than a direct consequence of spatial work arrangements.

Hypothesis 3 received partial support. Simple slope analyses revealed that the protective effect of colleague support on technostress—and specifically on techno-complexity and techno-invasion—was significant only among hybrid workers, not among on-site workers. These findings suggest that the effectiveness of social resources in reducing technostress strongly depends on the broader work system in which they operate. From a JD-R perspective, job resources are particularly beneficial under conditions of high demands (Bakker and Demerouti, 2007): the present findings suggest that the form of resource provision also matters. In hybrid settings, where ICT-mediated communication replaces spontaneous face-to-face interaction, perceived colleague support carries additional salience as a signal of relational availability and trust.

As a result, when support is perceived as present, its impact on reducing technological strain is amplified. This interpretation is consistent with recent studies on social wellbeing in hybrid work environments, which highlights how reduced face to face interaction weakens trust and increases psychological vulnerability (Lindeberg et al., 2024; Dale et al., 2024). Conversely, the non-significant buffering effect among on-site workers may reflect a saturation dynamic: when support is continuously available, it may lead employees to perceive it as a normative and implicit feature of the work environment, thereby reducing its salience as a distinct perceived resource. In other words, the buffering effect of colleague support may be less pronounced because support is more readily available through everyday interactions. This distinction between support as a perceived resource vs. support as an environmental given has been underexplored in the technostress literature and warrants further theoretical development.

Taken together, these findings highlight that the protective role of social resources is contingent upon the modality of work. Hybrid work arrangements, characterized by high technological mediation and reduced spontaneous interactions, appear to

amplify the importance of colleague support for maintaining employee wellbeing. These findings tentatively suggest practical implications for organizations in hybrid transitions: investing in the relational quality of hybrid teams may be as important as managing the technological infrastructure itself. This aligns with emerging evidence that organizational support is a critical resource against digital burnout in hybrid settings (Telu and Kumar, 2025; Peters and Gerards, 2025), and that sustainable wellbeing in flexible work arrangements depend not only on structural flexibility but on the quality of relational resources available to workers (Khedhaouria et al., 2024). However, given the cross-sectional design and the modest explained variance, these recommendations should be interpreted with caution and treated as directions for future intervention research rather than prescriptive guidelines.

5.1 Limitations and future directions

Despite the theoretical and practical contributions of the present study, several limitations should be acknowledged. First, it should be acknowledged that the R^2 values obtained across the regression models were modest, ranging from.031 to.051, indicating that colleague support and work modality together explain a relatively small proportion of the variance in technostress and its dimensions. While this is consistent with the broader occupational health literature, where cross-sectional models examining a limited set of predictors typically yield modest effect sizes (Bakker and Demerouti, 2007), it nonetheless calls for caution in interpreting the practical significance of the findings. The statistically significant effects observed—particularly the interaction between colleague support and work modality—should therefore be understood as meaningful but partial: colleague support operates as one important resource within a broader constellation of individual, organizational, and contextual factors shaping technostress. Future research incorporating additional predictors—such as leadership quality, organizational climate, and technological readiness—would likely yield greater explanatory power and offer a more complete account of the determinants of technostress in hybrid work settings.

Second, the research employed a cross-sectional design, which does not allow for causal inferences regarding the relationships between colleague support, work modality, and technostress. Although the findings are consistent with the assumptions of the JD-R model (Bakker and Demerouti, 2007), future research would benefit from longitudinal designs capable of capturing the dynamic interplay between technological demands, social resources, and employee wellbeing over time. Such approaches would facilitate a deeper understanding of how technostress evolves as employees adapt to dynamic technological environments and changing work arrangements. Another limitation is the composition of the sample that limited the possibility of fully comparing different work modalities. In particular, the subgroup of fully remote workers was underrepresented and therefore excluded from the analyses. Given that remote work typically involves even greater reliance on ICTs, future research should examine whether the patterns observed in the present study also apply to fully remote work arrangements, which may present different configurations of techno-demands and social resources. Additionally, the present analyses did not include sociodemographic and occupational control variables, such as age, gender, industry sector, or job role, despite evidence that these factors may be associated with technostress. This choice reflected the theoretical focus of the study on the JD-R-derived moderation model, as well as constraints related to sample size and the uneven distribution of occupational categories within the sample. Future research should examine whether the observed associations between colleague support, work modality, and technostress remain robust when accounting for these individual and occupational characteristics, and whether such factors interact with work modality in shaping employees' exposure to technostress creators.

Moreover, although the present study specifically focused on colleague support, the JD-R model highlights the importance of multiple organizational resources that can interact in shaping employees' responses to technological demands. In this context, working on-site represents an opportunity for the construction and strengthening of social support: physical proximity facilitates informal interactions, immediate exchanges of help and feedback, as well as the development of trustful relationships and daily cooperation. These dynamics can be understood through the lens of social and human capital, according to which social relationships constitute a fundamental resource for addressing work challenges and promoting performance improvement (Modesti et al., 2020; Marocco and Talamo, 2022). However, as Portes (1998) emphasized, mere membership in a social network does not guarantee concrete benefits: internal resources, such as individual skills and organizational capabilities, are necessary to transform potential social capital into actual operational advantages. To this aim, future research could explore how specific organizational and cultural factors, such as organizational climate, leadership styles, and organizational norms, or individual factors, such as employees' prior experience, influence the ability to access and benefit from social support, both in on-site and digitally mediated work contexts. Furthermore, the present study focused exclusively on colleague support as a social resource, without examining supervisor support or organizational support. While this focus was theoretically and contextually justified—colleague support being the resource most directly sensitive to variations in physical co-presence across work modalities—it remains possible that supervisor and organizational support operate through different mechanisms and may interact differently with work modality. Future research incorporating multiple sources of support simultaneously would provide a more comprehensive understanding of how the broader configuration of social resources shapes employees' experiences of technostress across different work arrangements. At the same time, further studies could examine organizational technological readiness—understood as the availability of digital infrastructure, tools, and competencies to support technology-mediated work—and examine how these resources may buffer technology-related demands, particularly those associated with techno-complexity.

Finally, future research could consider specific characteristics of remote work contexts, such as the physical workspace (private or shared), household composition, and other contextual conditions, such as the difference between public and private sector organizations, which may influence employees' experiences across various dimensions of technostress.

6 Conclusion

The present study contributes to the growing literature on human–technology interaction in contemporary workplaces by examining the relationships between colleague support, work modality, and technostress within the framework of the Job Demands–Resources model. The findings highlight that perceived colleague support represents a crucial social resource associated with lower levels of technostress and its core dimensions, confirming its protective role in work environments. At the same time, the results suggest that work modality alone does not necessarily determine employees' levels of technostress, as hybrid and on-site workers reported comparable levels of technological strain. Instead, the findings indicate that work modality shapes how social resources operate within digitally mediated work systems. In particular, colleague support appears to play a more pronounced protective role for hybrid workers, whose work activities rely more heavily on ICT-mediated communication and coordination. Overall, the study underscores the importance of conceptualizing technostress as an emergent phenomenon embedded within social and organizational contexts, rather than as a purely individual response to technology use. From an occupational safety and health perspective, these findings suggest that evolving organizations should invest not only in technological infrastructures but also in social infrastructures that foster collaboration, peer support, and informal knowledge sharing. Strengthening such social resources may represent a key strategy for promoting employee wellbeing and sustainable work practices in increasingly digitalized and flexible work environments.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans because data were collected exclusively through a voluntary, anonymous survey, and no sensitive personal information was obtained. All participants provided informed consent prior to participation, and anonymity was ensured throughout the data collection and analysis process. The study posed no foreseeable risk of harm to participants. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SM: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. TG: Investigation, Writing – original draft, Writing – review & editing, Conceptualization. EG: Data curation, Writing – original draft, Writing – review & editing, Investigation, Methodology. MS: Writing – original draft, Investigation. MC: Conceptualization, Supervision, Writing – review & editing, Investigation. FP: Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Writing – review & editing. AT: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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