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Original Article

Home as a new physical workplace: a causal model for understanding the inextricable link between home environment, work productivity, and well-being

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Abstract: The home has become a new physical workplace, and can therefore influence the work, health, and life of workers. This cross-sectional study aimed to evaluate the chronology of the effects of work hazards at home on factors such as workers' health, productivity, and well-being (WB). Information on novice working-from-home (WFH) workers was derived from the "Occupational health of WFH" project. The selected variables in the hypothesis model comprised problems such as perceived indoor environmental quality (IEQ), working conditions (WC), sick house syndrome (SHS), occupational stress (OS), work productivity (WP), and WB. The relationship between these variables was analyzed using a structural equation model. The group analysis results showed the following significant indirect path effects from work environment through WP: IEQ-> SHS->OS->WP. A non-significant direct effect was observed between IEQ and WP. While WC problems could also have a significant direct effect on WP, or be mediated by OS, WP is a significant consequence and a direct effect of WB. In conclusion, the WFH model's causal impact between home environment, WP, and WB is a physiopsychological pathway. Therefore, creating a healthy home environment and WC, along with OS management, comprise important issues for improving productivity and WB for this new work style.

Key words: Work style, Working-from-home, Work environment, Occupational stress, Sick house syndrome, Productivity, Well-being

Introduction

In the era of double disruption, massive technology advancement, accompanied by the unforeseen COVID-19 pandemic, has brought about an unprecedented and rapid transformation, especially in the workplace and working

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styles. An abrupt reverse shift—from traditional indoor workplaces or office-based work environments to a new geographic location, such as the home—has occurred, although without adequate concern or responsibility to address occupational health and safety issues[1]. The office, as a physical workplace location, has been gradually losing its importance, but the quality of the environment where one works and lives is an issue that has not changed.

According to International Labour Organization (ILO) estimates, in 2019, there were approximately 260 million home-based workers worldwide, representing 7.9% of global employment[1]. This number will likely to continue to grow in the post COVID world which has become the "new normal". Working-from-home (WFH) means an employee is working from their house, or place of residence, rather than working from their usual workplace. This new physical workplace issue poses challenges for Asian societies, particularly those adopting the traditional managerial approach (e.g., Thailand), where WFH is a less favored, but unavoidable practice due to the COVID-19 pandemic[2]. The latest survey results reveal that 20% of Thai companies have permanently switched to WFH to reduce the risks of COVID-19 infection[3].

Current WFH styles affect various work values. Indoor environmental quality (IEQ) is an occupational health concern related to WFH, given that the home is not designed to be a workplace. In 1986, the World Health Organization coined the term "sick building syndrome" (SBS)[4] to refer to health problems that emerge from IEQ. This problem has not declined over the past 40 years, but has only increased due to changes in human lifestyles, society, and environments. The IEQ problem is encountered not only in common indoor workplace settings, such as offices[5], hospitals[6], schools[7], and public utility buildings[8], but also in homes. Currently, sick house syndrome (SHS) refers to health problems that occur in specific residential settings. It was first reported in the 1990s[9] as a social problem in Japan, where it was defined in response to the perceived qualities of indoor work environment issues, and presented as a number of nonspecific symptoms, including mucosal irritation, respiratory problems, skin problems, or general health problems, without specifying their causation, but only specific attributes that occurred in certain homes[10].

In addition, the dissatisfaction caused by these environmental problems could be associated with psychosocial issues, such as occupational stress (OS), following an indirect influence on work, including increased working hours, decreased work efficiency or motivation, and disturbed work confidence until reaching work output[11]. Therefore, it is critical to investigate the chronological context, including the work environment and working conditions (WC), as well as consequences related to productivity, health effects, and basic demographic background information[12, 13]. Furthermore, previous studies found that workers WFH experienced WC issues such as a lack of private space, family members' interactions, inappropriate workstations, work equipment, or IT problems. As these problems could influence workers' efficiency and safety, their impact should also be a matter of concern[14, 15].

Moreover, WFH has had an impact on workers' health and performance, and by extension, on their well-being (WB)[16]. A considerable amount of information has been gathered on WFH interference and its presumed consequences. The ultimate goal is to promote employee WB, so as to maintain effective workplace functioning. WB is a multidimensional construct that integrates physical and mental health, resulting in more holistic approaches to public health. No single definition of WB exists, but a key and common element is that more than merely the absence of negative circumstances, such as illnesses, WB includes positive features, such as quality of life or happiness with one's work[17]. Therefore, as an aspect of life that implicitly affects WB, work should be the focus of promoting WFH among workers.

While preparing for the transition to WFH, and its progression in the near future due to the "new normal", employers must consider the effect of WFH on workers, particularly related to performance, health, and WB[18]. Knowledge on occupational health management and practice mechanisms is critical for a general understanding of how the home environment influences health, work, and WB. Currently, pre-existent and ongoing research is rather scarce on IEQ at home and as a contributor to work productivity (WP) and WB while WFH, regardless of the limited studies and interest in causal relationship issues. Previous studies have mostly focused on describing the advantages or disadvantages of WFH and its related factors[19], whereas the causal pathway, that ties elements of the built environment to outcomes and their impact is neither well-known nor consensual. In other words, few insights have been gathered regarding the causal nature of these relationships. Therefore, this objective of this study was to evaluate the chronology of the influence of the working environment, along with health, WP, and WB conditions, including the whole WFH group and individual personal characteristics. Gaining an understanding of why some workers respond to pro-environment behaviors can help to predict the necessary requirements for promoting their WB.

Participants and Methods

This cross-sectional study is part of the project on "Occupational health of working-from-home during the COVID-19 pandemic". It was approved by the Srinakharinwirot University Ethical Committee (SWUEC-130-2563E), and was conducted in compliance with recommendations from the Declaration of Helsinki. Anonymity and confidentiality were ensured in the administration and handling of data. Details of the methods that this study adopted are available in the study by Ekpanyaskul and Padungtod[20]. Briefly, the purposive sampling was conducted during the first wave of the COVID-19 pandemic, from May to June 2020. An online link for a self-administered questionnaire was sent to the administrators and then forwarded it to their staff in various organizations in the Bangkok metropolitan area. All of the targeted organizations were operating a WFH policy during the COVID-19 pandemic. Workers in these organizations (novices, as well as those WFH full-time and part-time), who voluntarily completed all the questions, were included in the study. By contrast, those who: (1) still worked full-time in their usual workplace for any reason; (2) submitted either duplicate or unreliable data; or (3) had no new-onset of WFH during the study period, were excluded.

This project's final database comprised the data of 869 Thai novices, and included various aspects of their WFH issues. However, the data were obtained from databases derived from hypotheses that utilized only seven data sets in the following categories: (1) demographic data; (2) perceptions of IEQ at home; (3) WC at home; (4) health problems related to SHS; (5) OS occurrence while WFH; and (6) WP while WFH, and (7) WB issues. The provenance and details of each variable from that data set were as follows:

(1) Demographic variables, including gender (male/female), age (<35, 35–45, >45 yr), type of WFH (full-time: 5–6 d per wk; part-time: 1–4 d per wk), educational levels (lower than a Bachelor's degree, Bachelor's degree and higher), and personality (openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism).

(2) IEQ problems of living spaces where work activities were performed were evaluated by self-assessing the perceived quality of the indoor physical work environment while WFH. These perceptions were adapted from a study by Ekpanyaskul and Jiamjarasrangsi[21], and comprised potential problems affecting the indoor work environment at home in eight categories: 1) lighting (too bright, too dim, and too much glare), 2) temperature (too hot or too cold), 3) dampness, 4) noise disturbances, 5) pet or insect disturbances, 6) poor ventilation or air, 7) odors, and 8) dust. Respondents were asked the question: "While working at home, have you experienced indoor environmental problems in...?". If workers reported any problems in the past one month or after starting WFH, the score was one point. Thus, the total score of IEQ problem variables ranged from 0–8.

(3) The problem of WC, which previous studies had shown to be a common challenge for WFH[22] included four aspects: 1) no privacy in work areas, 2) inappropriate work stations in terms of desks and chairs, 3) information technology problems (i.e., internet signals, software programs, and electrical supply), and 4) disturbance from family members. Respondents were asked the question: "While working at home, have you experienced working condition problems in...?". If the workers reported having faced problems relating to the above aspects in the past month or after starting WFH, a score of one point was assigned to each problem. Thus, the total score ranged from 0–4.

(4) The health problems selected in this study had two components. First, SHS-related information was obtained from physical health disturbances induced by the home environment or working area while WFH. Respondents were asked the question: "While working at home, have you at any time experienced symptoms in...?". The specific home environment was listed. The following diagnostic criteria were adapted from Miyajima *et al.*'s study[10]: (1) symptoms in the eyes, nose, throat, respiratory system, skin, or neurological system; and (2) symptom onset (only new or aggravated occurrence since WFH) that specifically appeared at home. If workers reported a single symptom in any system, a score of one point was assigned. Thus, the total score of the SHS variables ranged from 0–6. Second, OS variables while WFH were measured by self-assessment of stress, using a visual analog scale from 0–10, following the study by Lesage and Berjot[23].

(5) WP was measured by the feelings and behaviors that were perceived as performance results while WFH, as reported in previous studies[24, 25]. Respondents were asked the question: "Could you please compare the following changes or issues in the WFH period with your previous working life at a regular workplace or office before the COVID-19 outbreak?". The score was evaluated from six aspects: time management, effective work hours, work output, work efficiency, motivation to continue working, and confidence to make decisions. If a worker answered "increased during WFH compared to working in a regular workplace" to any of the questions, a score of one point

was assigned for each. Hence, the total score of WP variables ranged from 0–6.

(6) WB must also be considered while WFH. This study defined WB as "the combination of feeling good and functioning well," which was sufficiently broad and fitted with the study's relevant concepts (e.g., positive emotions such as happiness, contentment, control over one's life, experiencing positive relationships). The subjective WB variable was self-assessed using five aspects related to quality of life, work happiness, work satisfaction, work-life balance, and no mental health problems from WFH, such as burnout, depression, and anxiety[26–28]. Respondents were asked the question: "Could you please compare the following changes or issues in the WFH period with your previous working life at a regular workplace or office before the COVID-19 outbreak?". If the workers answered "increased or no mental problems during WFH compared to working in a regular workplace" to any of the questions, a score of one point was assigned for each. Thus, the total score of the subjective WB variable ranged from 0–5.

The variables taken from literature reviews were also checked for their content validity. IEQ perceptions, WC at home, and health problems related to SHS were checked by three experts in the occupational health field (occupational medicine physician, occupational health nurse, and industrial hygienist), whereas the WP and WB variables were checked by three experts in industrial and organizational psychology.

With regard to the causal model hypothesis, there is a great need to improve the understanding of the chronology of effects between the home environment and its work-related effects on physical and psychological health occurrences, as well as its consequences on workers' WP and WB, while WFH. Based on a literature review, an explanation for possible relationships between the variables in this study were hypothesized, as shown in Fig. 1.

For statistical analysis, all the variables selected from the database were rechecked for data reliability, such as all questions not answered in the same direction, and completeness of answers about the perception of IEQ, health problems, work performance, and WB prior to the data analysis. The data entry and statistical analysis for testing the hypotheses were performed using the M plus software program version 7.0 (Muthén & Muthén, Los Angeles, CA, USA).

The categorical data were presented by number and percentage, while the continuous data were presented by mean with 95% confidence intervals (CI), standard deviation, and range. The relationships between the variables

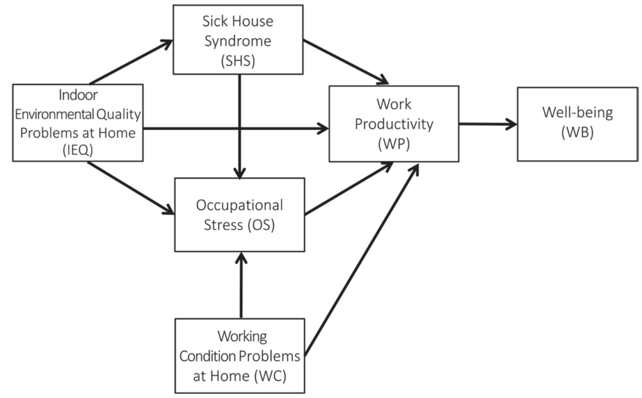

Fig. 1. Hypothesized relationship model between each variable in this study.

were analyzed using structural equation modeling (SEM) and the maximum likelihood estimation method[29]. The path standardized coefficients indicated the strength and direction of the relationship between two variables. Moreover, through appropriate final model fitting, the adequacy of the SEM was checked as follows: (1) χ^2 estimate indicating the difference between the observed and expected covariance matrices. This model's χ^2 value was close to zero, with $p>0.05$ indicating a good fit; (2) Comparative fit index (CFI) used the discrepancy function, and when adjusted for sample size, was >0.9 for an acceptable model fit; and (3) root mean square error of approximation (RMSEA) was related to the residual in the model, and an index of at least <0.06 was required for an acceptable model fit[30]. After the model was confirmed to be consistent and to have a good fit, it was examined by SEM. Thereafter, the significance of each path was calculated using a two-tailed *t*-test to assess the chronology of effects among the constructs. Results with a *p*-value of <0.05 were considered statistically significant.

Results

In the dataset utilized by this study, the participants' general characteristics were as follows: predominantly female, with a female to male ratio of 2.5:1; average age: 39.73 ± 9.82 yr; and 97.2% having a Bachelor's degree or higher. Regarding the participants' personality, conscientiousness and extraversion comprised the highest and lowest proportions, respectively. More than half of the participants were WFH part-time. The details of their characteristics are shown in Table 1.

Regarding the variables in the causal model, the mean, 95% CIs, standard deviation, and each variable's range are presented in Table 2.

The fitted causal model and its significant pathways of home environment, WP, and WB, are shown in Fig. 2. According to the results of its indices (χ^2=0.421, *df*=3, *p*=0.936, RMSEA<0.001, CFI = 1.000, TLI=1.000, SRMR=0.004), the estimated model provided a good fit for the data and could explain the WB variable at 34.7%.

In the analysis of all the groups, the significant indirect path effects from work environment through WB were as follows: SHS was mediated by IEQ problems, OS by SHS, WP by OS, and WB by WP (IEQ -> SHS -> OS -> WP). WP was affected by two paths. First, it showed a negative direct effect from poor WC. Second, it was mediated by OS, and affected by indoor environment, WC, or the SHS. The direct path effect between working environment and WP was not significant. While problems related to WC could have a significant negative direct effect on WP (WC->WP) as well, or mediation by OS (WC->OS->WP), WP is a consequence of a significant positive direct path to WB (WP->WB).

In terms of causal relationships, Table 3 presents the fit of the models through multi-group analyses in terms of gender, age groups, educational levels, personality types, and types of WFH. Moreover, except for the groups with lower education and personality types, such as extraversion, agreeableness, and neuroticism, in the final SEM, the same pattern of variables with a fitted model for all groups was found, from home environment to workers' well-being while WFH: (1) SHS was mediated by the indoor environment, OS by SHS, WP by OS, and WB by WP (IEQ -> SHS -> OS -> WP -> WP). In addition, among workers with higher education and conscientious personalities, WC also affected OS (WC->OS), and directly affected WP (WC->WP); (2) IEQ and SHS did not have a significant or direct effect on WP (IEQ-> WP and SHS-> WP), except for SHS that mediated WP among the male participants. The details and statistics of each of the general characteristics of WFH workers are shown in Table 3.

Table 1. General characteristics of the 869 participants

Variables	n (%)
Gender	
Male	252 (29.0)
Female	617 (71.0)
Age group (yr)	
<30	303 (34.9)
31–45	309 (35.6)
>45	257 (29.6)
Education	
Lower than Bachelor's degree	24 (2.8)
Bachelor's degree	404 (46.5)
Higher than Bachelor's degree	441 (50.7)
Personality	
Openness to experience	178 (20.5)
Conscientiousness	414 (47.6)
Extraversion	37 (4.3)
Agreeableness	186 (21.4)
Neuroticism	54 (6.2)
Type of WFH	
Fulltime	390 (44.9)
Part time	479 (55.1)

WFH: working-from-home.

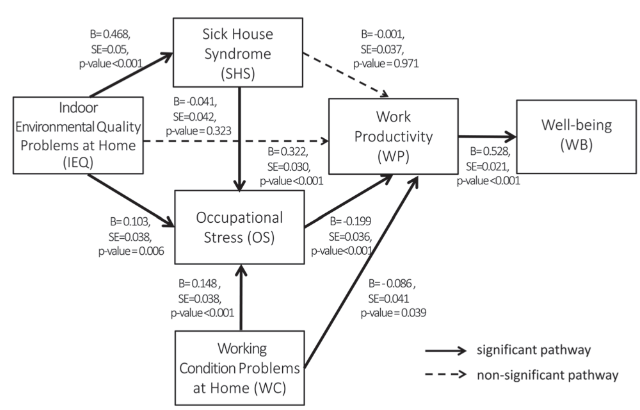

Fig. 2. Fitted path diagram of the home environment.

Table 2. Summarization of each variable in the causal model

Variables	Abbreviations in the model	Mean ± SD	95% CIs	Range
Perceived indoor environmental problems	IEQ	3.12 ± 2.34	2.96–3.27	0–8
Working condition problems	WC	2.06 ± 1.22	1.98–2.14	0–4
Sick house syndrome	SHS	1.07 ± 1.26	0.99–1.16	0–6
Occupational stress	OS	3.78 ± 2.69	3.61–3.96	0–10
Work productivity	WP	2.21 ± 2.11	2.07–2.35	0–6
Well-being	WB	2.10 ± 1.69	1.98–2.21	0–5

SD: standard deviation; 95% CI: 95% confidence interval.

Table 3. Standardized coefficients (β), and standard error (SE) of final structural equation stratified by general characteristics of working-from-home (WFH) workers

General characteristics	Standardized coefficients (Standard error)								
	IEQ -> SHS	IEQ -> OS	IEQ -> WP	WC -> OS	WC -> WP	SHS -> OS	SHS -> WP	OS -> WP	WP -> WB
Gender									
Male	0.54	0.176	<0.001	0.072	–0.042	0.284	–0.148	–0.161	0.526
	(0.094)*	(0.069)*	(0.077)	(0.072)	(0.076)	(0.057)*	(0.067)*	(0.065)*	(0.039)*
Female	0.442	0.081	–0.063	0.176	–0.094	0.334	0.059	–0.219	0.526
	(0.058)*	(0.045)	(0.050)	(0.044)*	(0.049)	(0.035)*	(0.044)	(0.043)*	(0.026)*
Age group (yr)									
<30	0.451	0.052	–0.041	0.144	–0.102	0.342	–0.086	–0.186	0.502
	(0.086)*	(0.064	(0.069)	(0.063)*	(0.067)	(0.051)*	(0.062)	(0.059)*	(0.037)*
30–45	0.500	0.031	–0.089	0.202	0.054	0.305	0.030	–0.188	0.554
	(0.082)*	(0.064)	(0.071)	(0.064)*	(0.071)	(0.051)*	(0.063)	(0.062)*	(0.035)*
>45	0.426	0.224	0.053	0.079	–0.271	0.325	0.054	–0.229	0.512
	(0.092)*	(0.069)*	(0.077)	(0.071)	(0.074)*	(0.053)*	(0.065)	(0.065)*	(0.041)*
Education									
Lower than Bachelor's degree	0.139	0.186	0.022	0.331	0.212	0.312	–0.127	–0.325	0.662
	(0.189)	(0.172)	(0.209)	(0.189)	(0.226)	(0.176)	(0.215)	(0.222)	(0.095)*
Bachelor's degree	0.337	0.162	–0.099	0.036	–0.003	0.343	–0.088	–0.149	0.481
	(0.043)*	(0.055)*	(0.062)	(0.056)	(0.060)	(0.043)*	(0.054)	(0.053)*	(0.033)*
Higher than Bachelor's degree	0.348	0.05	0.02	0.234	–0.161	0.300	0.053	–0.219	0.564
	(0.041)*	(0.054)	(0.059)	(0.053)*	(0.059)*	(0.043)*	(0.051)	(0.050)*	(0.029)*
Personality									
Openness to experience	0.491	0.175	–0.040	0.173	–0.103	0.208	–0.118	–0.230	0.527
	(0.119)*	(0.081)*	(0.087)	(0.080)*	(0.085)	(0.070)*	(0.077)	(0.075)*	(0.046)*
Conscientiousness	0.43	0.088	–0.018	0.122	–0.187	0.369	0.062	–0.251	0.536
	(0.076)*	(0.053)	(0.058)	(0.053)*	(0.057)*	(0.041)*	(0.052)	(0.051)*	(0.031)*
Extraversion	0.511	–0.107	–0.261	0.306	0.099	0.472	0.077	–0.156	0.635
	(0.184)*	(0.206)	(0.249)	(0.200)	(0.244)	(0.124)*	(0.197)	(0.181)	(0.080)*
Agreeableness	0.564	0.106	–0.107	0.145	0.054	0.372	0.001	–0.097	0.529
	(0.098)*	(0.082)	(0.096)	(0.084)	(0.098)	(0.064)*	(0.086)	(0.084)	(0.048)*
Neuroticism	0.457	0.068	–0.140	0.215	0.173	0.097	–0.080	–0.232	0.356
	(0.178)*	(0.171)	(0.175)	(0.170)	(0.176)	(0.133)	(0.139)	(0.135)	(0.107)*
Type of WFH									
Fulltime	0.478	0.113	–0.028	0.105	–0.067	0.326	0.007	–0.249	0.534
	(0.066)*	(0.052)*	(0.057)	(0.052)*	(0.056)	(0.041)*	(0.050)	(0.048)*	(0.028)*
Part time	0.459	0.112	–0.054	0.192	–0.110	0.304	–0.014	–0.146	0.518
	(0.075)*	(0.055)*	(0.062)	(0.055)*	(0.062)	(0.044)*	(0.055)	(0.054)*	(0.033)*

*p-value <0.05.

IEQ: indoor environmental quality at home; WC: working conditions; SHS: sick house syndrome; OS: occupational stress; WP: work productivity; WB: well-being.

Discussion

This study focused on the scope of built and indoor environmental perspectives. Therefore, its aim was to investigate the causal model and explained the inextricable link between home environment factors such as IEQ, WC, influence of IEQ on physical health and SHS, psychological health effects of WFH, WP, and WB among novices WFH. Moreover, this issue was also examined in terms of the participants' different personal backgrounds. The results revealed that home environments had a direct effect on WFH workers in terms of physical effects, including SHS, and the psychological effects of OS. IEQ and SHS had no direct effect on WP, which had to be mediated by

OS in a similar way as WC as mediated. Additionally, WP can be directly correlated with WB at a higher level.

This causal model found that home environments contribute to physiopsychological functions in many complex and important ways regarding workers' responses to the environment. This pathway showed the same pattern for full-time and part-time WFH, referring to the specific environment, but with different personal characteristics such as age, gender, education, and personality. This indicates that personal factors could also be susceptible to this causation[12, 13, 31, 32]. Despite increasing knowledge of work environment hazards, various workplaces still frequently struggle with poor WC and an unsafe climate[33]. Furthermore, the consequences are not limited to ill-health. Workers who experience work environment problems can also experience a decreased ability to work or decreased desire to work, resulting in a loss of productivity for the company[24]. By contrast, ensuring a good physical and psychological environment at work could improve the speed and accuracy of the tasks performed. These work-related issues are a surrogate effect of WFH well-being[34].

The causal model's results may be explained in the context of environmental psychology, and through understanding the interaction between humans and their physical and psychosocial environments. Regarding the concept of "the theory of place"[35], this study aimed to clarify and solve complex environmental problems in the pursuit of individual WB, within wider society. When workers use their homes as a workplace, poor environmental quality housing harms the physical and socioemotional health of them[36]. They are able to evaluate which properties fulfill their various needs in different environments, more so because homes have components that provide biological, social, psychological, and/or cultural satisfaction. Through their past experiences in traditional workplaces, they are able to intrinsically define and reflect on their personal values, attitudes, feelings, and beliefs about the physical environment[37]. Consequently, their extrinsic behavior was expressed through mental health illnesses, work productivity, etc., and was reflected in their WB in both positive and negative ways[38].

Several limitations of this study should be noted. First, owing to its cross-sectional design, the results pathway derived from statistical analyses was not reflected in temporal relationships. Therefore, it is necessary to conduct further longitudinal studies to observe causal relationship models[39], to mitigate the health effects or negative psychological impacts of working environments and conditions, and to foster better WB. Moreover, the fitted model could only explain the WB of workers at 34%. Numerous factors, particularly organizational ones, that contribute to the WB of WFH workers were not included in this model[17, 18]. Therefore, future studies should include additional factors to better explain and prove this causation. Second, as this study was conducted during the lockdown of the first wave of the COVID-19 pandemic, participants may have experienced stress from many sources, such as the fear of being infected; the shutdown of the healthcare system; economic recession or lockdown; and organizational factors, including social isolation, presenteeism, lack of support, career promotion, and the blurring of boundaries. These sources may have confounded the psychological issues caused by the working environment and conditions. Third, this study used secondary data, which was selected from the OH project database and a construct of proxy variables for each parameter, which may not have covered all the dimensions or components of each parameter. Each of these parameters were also evaluated subjectively through a questionnaire survey. Some parameters were measured by single-items with good psychometric properties[40], and could be criticized for their lack of measurement reliability. Therefore, objective measurements should also be conducted. In addition, the study relied exclusively on self-reporting measures, which could have resulted in an overestimation of the statistical associations found owing to the common method variance.

In terms of recommendations, human capital is considered one of the most important factors of productivity. Workers' WB encompasses assets that can be used to create more resources, which in turn, generate benefits for organizations. Employers need to play a pivotal role through providing support to workers, which strongly influences how well basic needs that determine health and WB are met. Life in the "new normal" after the pandemic or the future uncertain situation necessitates not only handling new working styles, such as WFH, but also addressing or redesigning occupational health strategies to potentially promote healthy work from the physical and psychosocial home environment to encourage workers' WP and WB, and enable their continued work. Accordingly, productivity improvements, a good residential environment, and the importance of appropriately enhancing the working environment and WC when WFH, were suggested. The relevant authorities should provide practical WFH guidelines on how to promote the value of work in terms of WP and WB in this causal model. Thus, through the implementation of interventions and supported measures, WFH workers might benefit particularly from healthy IEQ; appropriate

WC; and psychological interventions such as OS management, employee assistance programs, and specific mental health problem considerations. Moreover, the health surveillance system should foster WFH workers' WB, physical and mental health, and health-related WC and OS in relation to SHS, which might benefit WFH workers for the early detection of the negative consequences of such health effects.

In conclusion, this study identified some potentially negative indoor home environments, WC, and their effects on WFH workers regarding work outcomes and WB. The developed model explains the pathway of how the factors of work, health, productivity, and workers' WB are inextricably linked, and comprise complex interactions between physiological and psychological pathways. It could also lead to an increased understanding of the impact of new workplaces (such as homes) on workers. Hence, these findings have practical implications for promoting the appropriate maintenance of WC in residential environments, accompanied by OS management to improve productivity and WB while WFH.

Authors' Contribution

Conceptualization: CE, CP. Data curation: CE, CP. Formal analysis: CE, CK. Funding acquisition: CE. Methodology: CE, CK. Project administration: CE. Visualization: CE. Writing − original draft: CE. Writing − Review & editing: CP, CK.

Conflict of Interest

On behalf of all of the authors, there is no relevant or potential conflict of interest in this study.

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References

1) International Labour Office (2021) Working from home: from invisibility to decent work, International Labour Office, Geneva.
2) Tanpipat W, Lim HW, Deng X (2021) Implementing remote working policy in corporate offices in Thailand: strategic facility management perspective. Sustainability **13**, 1284.
3) Himawan KK, Helmi J, Fanggidae JP (2022) The sociocultural barriers of work-from-home arrangement due to COVID-19 pandemic in Asia: implications and future implementation. Knowl Process Manage **29**, 185–93.
4) World Health Organization (1982) Indoor air pollutants: exposure and health effects, Report on a WHO meeting, Nördlingen, 8–11 June 1982, EURO reports and studies, 78 World Health Organization, Regional Office for Europe, Copenhagen.
5) Carrer P, Wolkoff P (2018) Assessment of indoor air quality problems in office-like environments: role of occupational health services. Int J Environ Res Public Health **15**, 741.
6) Hiwar W, King MF, Shuweihdi F, Fletcher LA, Dancer SJ, Noakes CJ (2021) What is the relationship between indoor air quality parameters and airborne microorganisms in hospital environments? A systematic review and meta-analysis. Indoor Air **31**, 1308–22.
7) Osborne S, Uche O, Mitsakou C, Exley K, Dimitroulopoulou S (2021) Air quality around schools: part I—a comprehensive literature review across high-income countries. Environ Res **196**, 110817.
8) Śmiełowska M, Marć M, Zabiegała B (2017) Indoor air quality in public utility environments—a review. Environ Sci Pollut Res Int **24**, 11166–76.
9) Seki A, Takigawa T, Kishi R, Sakabe K, Torii S, Tanaka M, Yoshimura T, Morimoto K, Katoh T, Kira S, Aizawa Y (2007) Review of sick house syndrome. Jpn J Hyg **62**, 939–48 (in Japanese).
10) Miyajima E, Tsunoda M, Sugiura Y, Hoshi K, Kido T, Sakamoto Y, Sakabe K, Aizawa Y (2015) The diagnosis of sick house syndrome: the contribution of diagnostic criteria and determination of chemicals in an indoor environment. Tokai J Exp Clin Med **40**, 69–75.
11) Hui FKP, Aye L (2018) Occupational stress and workplace design. Buildings **8**, 133.
12) Girma B, Nigussie J, Molla A, Mareg M (2021) Occupational stress and associated factors among health care professionals in Ethiopia: a systematic review and meta-analysis. BMC Public Health **21**, 539.
13) Kawakubo S, Arata S (2022) Study on residential environment and workers' personality traits on productivity while working from home. Build Environ **212**, 108787.
14) Xiao Y, Becerik-Gerber B, Lucas G, Roll SC (2021) Impacts of working from home during COVID-19 pandemic on physical and mental well-being of office workstation users. J Occup Environ Med **63**, 181–90.
15) Gabr HM, Soliman SS, Allam HK, Raouf SYA (2021) Effects of remote virtual work environment during COVID-19 pandemic on technostress among Menoufia University Staff, Egypt: a cross-sectional study. Environ Sci Pollut Res Int **28**, 53746–53.
16) Nakrošienė A, Buciuniene I, Goštautaitė B (2019) Working from home: characteristics and outcomes of telework. Int J Manpow **40**, 87–101.

17) The Health Related Quality of Life (HRQOL) program, CDC's Division of Population Health Well-being concepts. https://www.cdc.gov/hrqol/wellbeing.html. Accessed January 5, 2021.
18) Schulte P, Vainio H (2010) Well-being at work—overview and perspective. Scand J Work Environ Health **36**, 422–9.
19) Chirico F, Zaffina S, Di P, Reparata R, Giorgi G, Ferrari G, Capitanelli I, Sacco A, Szarpak Ł, Nucera G, Taino G, Afolabi A, Ilesanmi O (2021) Working from home in the context of COVID-19: a systematic review of physical and mental health effects on teleworkers. J Health Soc Sci **6**, 319–32.
20) Ekpanyaskul C, Padungtod C (2021) Occupational health problems and lifestyle changes among novice working-from-home workers amid the COVID-19 pandemic. Saf Health Work **12**, 384–9.
21) Ekpanyaskul C, Jiamjarasrangsi W (2004) The influence of indoor environment quality on psychosocial work climate among office workers. J Med Assoc Thai **87** Suppl 2, S202–6.
22) Salamone F, Barozzi B, Bellazzi A, Belussi L, Danza L, Devitofrancesco A, Ghellere M, Meroni I, Scamoni F, Scrosati C (2021) Working from home in Italy during COVID-19 lockdown: a survey to assess the indoor environmental quality and productivity. Buildings **11**, 660.
23) Lesage FX, Berjot S (2011) Validity of occupational stress assessment using a visual analogue scale. Occup Med (Lond) **61**, 434–6.
24) Al Horr Y, Arif M, Kaushik A, Mazroei A, Katafygiotou M, Elsarrag E (2016) Occupant productivity and office indoor environment quality: a review of the literature. Build Environ **105**, 369–89.
25) Awada M, Lucas G, Becerik-Gerber B, Roll S (2021) Working from home during the COVID-19 pandemic: Impact on office worker productivity and work experience. Work **69**, 1171–89.
26) Ruggeri K, Garcia-Garzon E, Maguire Á, Matz S, Huppert FA (2020) Well-being is more than happiness and life satisfaction: a multidimensional analysis of 21 countries. Health Qual Life Outcomes **18**, 192.
27) Weitzer J, Papantoniou K, Seidel S, Klösch G, Caniglia G, Laubichler M, Bertau M, Birmann BM, Jäger CC, Zenk L, Steiner G, Schernhammer E (2021) Working from home, quality of life, and perceived productivity during the first 50-day COVID-19 mitigation measures in Austria: a cross-sectional study. Int Arch Occup Environ Health **94**, 1823–37.
28) Niu Q, Nagata T, Fukutani N, Tezuka M, Shimoura K, Nagai-Tanima M, Aoyama T (2021) Health effects of immediate telework introduction during the COVID-19 era in Japan: a cross-sectional study. PLoS One **16**, e0256530.
29) Maydeu-Olivares A (2017) Maximum likelihood estimation of structural equation models for continuous data: standard errors and goodness of fit. Struct Equ Modeling **24**, 383–94.
30) Chan YH (2005) Biostatistics 308. Structural equation modeling. Singapore Med J **46**, 675–9, quiz 680.
31) Putus T, Vilén L, Atosuo J (2021) The association between work-related stress, indoor air quality, and voice problems among teachers is there a trend. J Voice S0892-1997(21)00307-6.
32) Seva RR, Tejero LMS, Fadrilan-Camacho VFF (2021) Barriers and facilitators of productivity while working from home during pandemic. J Occup Health **63**, e12242.
33) Katz AS, Pronk NP, McLellan D, Dennerlein J, Katz JN (2019) Perceived workplace health and safety climates: associations with worker outcomes and productivity. Am J Prev Med **57**, 487–94.
34) Diamantidis A, Chatzoglou P (2018) Factors affecting employee performance: an empirical approach. Int J Prod Perform Manag **68**, 171–93.
35) Gifford R (2014) Environmental psychology matters. Annu Rev Psychol **65**, 541–79.
36) Evans GW, Wells NM, Chan HY, Saltzman H (2000) Housing quality and mental health. J Consult Clin Psychol **68**, 526–30.
37) Peng J, Strijker D, Wu Q (2020) Place identity: how far have we come in exploring its meanings? Front Psychol **11**, 294.
38) Steffgen G, Sischka PE, Fernandez de Henestrosa M (2020) The quality of work index and the quality of employment index: a multidimensional approach of job quality and its links to well-being at work. Int J Environ Res Public Health **17**, 7771.
39) Rosner D (2015) Criteria for action in population health: the Hill criteria a half century later. Milbank Q **93**, 259–62.
40) Fisher GG, Matthews RA, Gibbons AM (2016) Developing and investigating the use of single-item measures in organizational research. J Occup Health Psychol **21**, 3–23.