The potential of high-performance workplaces for boosting worker productivity, health, and creativity: A comparison between WELL and non-WELL certified environments

Samin Marzban [a,*], Christhina Candido [b], Behnaz Avazpour [b], Martin Mackey [c], Fan Zhang [d], Lina Engelen [e], Dian Tjondronegoro [f]

[a] School of Civil, Mining, Environmental and Architectural Engineering, Faculty of Engineering and Information Sciences, University of Wollongong, Northfields Ave, North Wollongong, NSW, 2500, Australia
[b] Melbourne School of Design, Faculty of Architecture, Building and Planning, The University of Melbourne, Melbourne, VIC, Australia
[c] School of Health Sciences, The University of Sydney, Sydney, NSW, Australia
[d] School of Engineering and Built Environment, Griffith University, Brisbane, QLD, Australia
[e] School of Public Health, The University of Sydney, Sydney, NSW, Australia
[f] Department of Business Strategy and Innovation, Griffith University, Brisbane, QLD, Australia

ARTICLE INFO

ABSTRACT

Although there is abundance of research on Indoor Environmental Quality (IEQ) in offices, aspects beyond IEQ that can affect occupants' satisfaction and performance are not well understood. Additionally, rapid adaptation of certification schemes and scarcity of evidence in evaluating if the workplaces with these schemes outperform other workplaces necessitate research in this area. In this study, a total of 1403 Post-Occupancy Evaluation surveys from 14 open-plan offices (10 WELL-certified and 4 uncertified) in Australia, New Zealand and Hong Kong were analysed. Key drivers of productivity, creativity, and health were investigated. Satisfaction with visual privacy and access to the outdoor environment emerged as key predictors for productivity, and layout and interior design was the main predictor for creativity. Organizational aspects were the key drivers for mental health; privacy and IEQ for physical health; and privacy and connection to the outdoor environment for overall health. The five offices that achieved the highest satisfaction in layout and interior design, IEQ, privacy and connection to the outdoor environment, and organizational aspects were all WELL certified, so a comparison was conducted between WELL and non-WELL offices. Satisfaction with the physical configuration of the space and organizational aspects were generally higher in WELL-certified offices. There were no significant differences in health between WELL and non-WELL offices, however fewer Sick Building Syndrome (SBS) complaints and musculoskeletal discomfort were less reported in WELL offices. More than 20% of respondents were dissatisfied with the physical environment regardless of being WELL or non-WELL certified.

1. Introduction

Open-plan offices have been the dominant typology adopted by the corporate real estate market in the last decades. The widespread adoption of open plan offices is grounded on their cost-effectiveness [1], flexible physical design [2], enhanced communication between the workers [2,3], improved company culture [4] and individual/organizational productivity [5]. This office typology was on the rise before COVID-19 with varying degrees of success despite the constant push back from workers due to low performance of the physical environment. The low performance for open-plan typology was mostly due to Indoor Environmental Quality (IEQ) [6–8], especially acoustic-related issues [8,9]. With the physical environment of open-plan offices under constant scrutiny and comments by occupants, the push for and investment in lifting the performance of offices was increasing even before COVID with a view to better supporting work tasks, boosting productivity whilst attracting and retaining talent. Post-COVID the large-scale adoption of remote working has allowed workers to produce bespoke home office set-ups that are deemed superior to office HQs (Head Quarters), especially when it comes to

developing work that requires concentration [10]. As a result, it is expected that the tolerance for low-performing workplaces is likely to decrease post-COVID and there is renewed interest in delivering high-performance workplaces for industry. But what is a high-performance workplace?

Although there is no accurate definition of a high-performance open-plan office, it has been characterized as including attributes such as excellence of IEQ, interior design, sustainability, safety, engagement, workplace experience, aesthetics, health, and occupant productivity. However, much of the current literature on high performance offices emphasize the role of IEQ (excluding acoustics), acoustics and privacy, and new ways of working. For IEQ, thermal comfort and air quality [11, 12], visual comfort and access to daylight [1,13], and personal control [14] have been the focus of several studies. A study conducted by Baird et al. (2012) [15] investigated all these factors in relation to operational, environmental, personal control, and satisfaction aspects comparing sustainable and conventional buildings. The relationships between IEQ aspects and satisfaction [7], productivity [16] and/or job satisfaction [17] have been also investigated. Collectively, these studies outline a critical role of IEQ in determining occupants' satisfaction and dissatisfaction in open-plan offices. Several studies have also focused on the well-known issues of open-plan offices, including noise [18,19], privacy [3], and speech intelligibility [20]. Results from different studies in open-plan offices have linked excessive noise and lack of privacy to poor perceived worker productivity and performance and concentration [21]. For 'future ways of working', studies have investigated some aspects of physical configuration of the workspace and interior design [22], with a focus on activity-based and flexible working [23–25] on a rise before the pandemic.

To achieve the status of high-performance, industry has long adopted various certifications as pathways. At first, the push was towards low energy and sustainable buildings which are the backbone of tools such as LEED (Leadership in Energy and Environmental Design) and BREAM (Building Research Establishment Environmental Assessment Method). Liang et al. (2014) [26] showed significant improvements in satisfaction in IEQ when comparing green-certified and conventional workplaces. Lee et al. (2020) [27] also reported higher satisfaction with IEQ and health in buildings which achieved a Green Mark standard. Study by Thatcher and Milner (2016) [28] investigated the impact of Green certified buildings on health and wellbeing among three offices. Their study indicated perceived physical wellbeing increased significantly for one of the buildings, providing further support for the positive impact of the green buildings. On the contrary, Altomonte et al. (2019) [29] reported that achievement of a specific IEQ credit −15 credits under LEED for New Construction (LEED-NC) and LEED for Existing Buildings (LEED-EB), and 17 under LEED for Commercial Interiors (LEED–CI)– did not considerably increase satisfaction with the corresponding IEQ factor. Altomonte and Schiavon (2013) [30] found insignificant differences between LEED and conventional buildings for air quality and thermal comfort. MacNaughton et al. (2017) [31] also reported higher scores in cognitive tests and sleep quality, as well as fewer sick building symptoms in high-performing, green certified buildings. While these outcomes may be influenced by IEQ, the findings of this study suggest that the benefits of green certification standards extend beyond measurable IEQ factors [31]. Similarly, in a study conducted by Khoshbakht et al. (2022) [32], there was a negligible improvement in the environmental parameters of green certified buildings compared to non-certified buildings. However, significant differences were observed between the two building groups in terms of operational parameters such as design, needs, image of the building, and cleaning.

Over the last decade, the high-performance goal post shifted towards health and wellbeing certification, and since then, premises certified under this flagship are accepted and celebrated in industry as high-performance. Indeed, the rapid uptake of health and wellbeing certification tools and schemes in the corporate real-estate market is evidence for this growing appetite for high-performance workspace in the industry. Along with the shift to prioritize human health, several international certification tools such as Fitwel [33] and WELL [34] emerged in the industry going beyond IEQ to consider human health. WELL is the fastest growing tool with the target of transforming buildings and organizations to advance health and well-being to help people thrive. The number of WELL-certified buildings in the Asia Pacific has doubled between 2020 and 2021 to nearly 80 million square metres, with Australia leading the market with about 25% of commercial office space now WELL-enrolled as preparation for return to the workplaces after COVID-19 [35].

While the older international certificates (e.g. LEED and BREEAM) are well investigated in several studies [36–38], evidence on how WELL-certified workplaces perform is still scarce. There have been very limited number of studies on the topic recently with a Scopus search showing that the number of papers published with WELL in their title, abstract or keyword do not exceed five. For example, Candido et al. (2021b) [24] reported higher overall satisfaction, workability, perceived productivity, and health for WELL-certified premises. When comparing WELL and non-WELL certified offices, the biggest differences in average scores were found on occupants' satisfaction with Furniture, fixtures and ergonomics and connection to outdoor environment. Floor plan analyses showed that WELL-certified premises incorporated a variety of spaces purposely allocated for different activities, from concentration to collaboration. Licina and Yildirim (2021) [39] compared occupants satisfaction scores with the IEQ before and after relocation from three non-WELL (two BREEAM and one conventional) to three WELL-certified office buildings. They found a statistically significant increase in building and workspace satisfaction after relocation to WELL buildings for two out of three building pairs. In a mixed methods study, Licina and Langer (2021) [40] reported that although the WELL-certified buildings recorded higher levels of air pollutants associated with paint, there was statistically significant improvement in satisfaction with indoor air quality after relocation into WELL offices regardless of the air pollution levels. An analysis of over 1300 longitudinal pre- and post-occupancy survey responses conducted by Ildiri et al. (2022) [41] showed that transitioning from non-WELL certified offices to WELL certified offices had a positive impact on occupant satisfaction with the workplace, as well as occupant perceived health, well-being, and productivity. The analysis revealed a statistically significant difference in means between the pre- and post-occupancy periods.

There are two research gaps that this study is addressing: 1) Although the research on IEQ of high-performance open-plan offices is relatively rich, little research has investigated aspects beyond IEQ that may affect occupants' satisfaction and performance in high-performance open-plan offices. Identification of the design strategies that are highly rated by occupants and assist in gathering evidence around methods to transform an average open-plan office to a high-performance office is also limited. If we consider high-performance offices (whether certified or not) as the success stories that we can learn from, it is also not clear what parameters drive higher satisfaction rates, productivity, health, and creativity in these offices. 2) Despite the rapid adoption of health-related certification schemes such as WELL around the world, there is a scarcity of empirical evidence arising from such workplaces about their superiority of achieving higher occupants' satisfaction and health. While studies like Ildiri et al. (2022) [41] have reported higher perceived health in WELL-certified offices compared to non-WELL certified offices, there is still little research on the differences between WELL-certified and non-WELL certified workplaces in terms of occupant's satisfaction with the physical environment, organizational aspects and their perceived health.

Therefore, the main aim of this study is to first investigate the drivers of occupants' productivity, creativity, and health in high-performance workplaces, and second to explore the differences between WELL-certified and non-WELL-certified workplaces regarding occupants' satisfaction and perceived health in an attempt to test if the certifications work. This study sets out to assess occupants' satisfaction with the

physical environment (inc. IEQ), and organizational aspects, and user-reported sick building syndrome and musculoskeletal discomfort to examine health-related aspects in WELL and non-WELL work environments. Data from a total of 1403 Post-Occupancy Evaluation surveys collected from 14 organizations in Australia, New Zealand and Hong Kong were analysed in this study.

2. Methodology

2.1. Workplaces and organizations

Fourteen organizations in Australia, New Zealand and Hong Kong volunteered to take part in this study by reaching out to the researchers to use the survey tool for certification purposes. The basic information about these 14 workplaces is summarized in Table 1. All these workplaces are open-plan offices with traditional, Activity-Based Working (ABW) and/or Agile as the way of working introduced by the organization and supported by the physical configuration of the space. In workspaces designed to support traditional ways of working, each worker has an assigned desk. ABW and agile are two terms that have been used interchangeably and are similar in the flexibility given to the occupants and desk ownership is removed. In all offices studied here, individuals change their location based on the work activity at hand and their preferences, regardless of desk ownership arrangements. The workplaces were towards the high-end open plan offices in Australia, hence a variety of space types (zones) and work settings such as concentration and focused work, collaboration and teamwork, impromptu and formal meetings are designed in work environments investigated here.

The organizations who occupied the studied workspaces are from construction, consultancy, property, government, education, telecommunication, finance, medical and property industry sectors. Out of 14 organizations, 10 are either already awarded a WELL certification tool, or they are pursuing it at the tenancy level. This means that they must meet preconditions in the International WELL building standard, as the foundation of a healthy building for all levels of WELL certification [34]. Four other organizations had not been awarded a WELL certification, nor were pursuing this certification. These workspaces are marked as "non-WELL" in Table 1.

2.2. The Sustainable and Healthy Environments (SHE) survey

The SHE (Sustainable and Healthy Environments) Post-Occupancy Evaluation (POE) surveys for workplaces were conducted and analysed for this study. The survey questions are designed to collect data about human, organizational (or institutional) and environmental-related variables from offices, residential/student accommodation, and educational premises. The SHE workplace survey features questions

about occupants' sociodemographic, occupancy and working arrangement, commuting type and length, IEQ, workplace layout, workplace ergonomics and aesthetics, water availability and intake, nutrition, sleep, workplace wellness and engagement, physical and mental health. The questionnaire also incorporates overall evaluation including perceived links between workplace productivity, creativity, health, and organizational culture. The SHE questionnaire uses seven-point Likert scale (1 = lowest rating, 4 = neutral and 7 = highest rating), multiple options and open-ended questions. It also has a branch structure to allow dissatisfied occupants to provide their reason for dissatisfaction with different aspects related to the physical configuration of their workplace. The survey is endorsed for use by IWBI WELL v2, Green Building Council of Australia (GBCA) and National Australian Built Environment Rating System (NABERS).

Data from a total of 1403 SHE POE surveys were analysed for this study. The surveys were conducted online through Qualtrics, and ethics approval was sought before starting the project. The survey link was issued by the researchers and distributed by the organization. The link was sent to all office staff in each organization. The participation was voluntarily and anonymous, and no bonus/award was provided for the respondents. Each survey link was left open for initially two weeks and this period was extended in some cases based on the organization's request.

2.3. Occupants

Respondents were mostly working in their office at the time of surveys. Less than 5% of the respondents indicated that they were working remotely, however they were asked to answer survey questions considering their experience at their workplace. Respondents' background information was collected with the first set of questions in the survey tool (Table 2). The 1403 respondents (54.1% females) were mostly in Generation Y/Millennials (born 1980–1994, 43%) and Generation X (born 1965–1979, 36.5%) with 42.2% having a Bachelor's degree and 27.6% having a post-graduate degree. The majority (85.6%) of the respondents were working full-time, with around half of them (47.9%) as professional and 28.2% as managers and administrators. Most respondents (75.9%) were also working between 31 and 50 h per week.

Females (33.6%) and male (48.7%) distributions in WELL offices were similar to the whole sample, however the percentage of female respondents (71.1%) was higher compared to male respondents (26.5%) in non-WELL offices. Similarly, respondents in Generation Y were greater than Generation X (48.8% vs 33.6%), but in WELL offices Generation X respondents were more frequent (41.7% vs 33.0%) (Table 2).

Table 1
Basic information about surveyed offices.

Office	Sample size	Respondents	Response rate (%)	Certification	Industry
1	400	120	30	WELL	Construction
2	40	23	58	WELL	Consultancy
3	32	24	75	Non- WELL	Property
4	525	147	31	Non- WELL	Government
5	155	75	48	WELL	Construction
6	39	28	71	WELL	Construction
7	165	69	42	WELL	Education
8	1000	330	33	WELL	Telecommunications
9	220	114	52	WELL	Telecommunications
10	65	56	86	WELL	Finance
11	90	55	61	WELL	Medical equipment
12	48	24	50	WELL	Property
13	3200	256	8	Non-WELL	Medical
14	800	82	10	Non- WELL	Insurance
		Total = 1403	Average = 47		

Table 2
Basic information of the respondents for all (n = 1403), WELL (n = 894), and non-WELL (n = 509).

		All		WELL		Non-WELL	
		Count	N%	Count	N%	Count	N%
Gender	Female	759	54.1	397	44.4	362	71.1
	Male	613	43.7	478	53.5	135	26.5
	Intersex, Other and Prefer not to respond	31	2.2				
Birth year	1946–1964	157	11.2	61	6.8	96	18.9
	1965–1979 (Generation X)	512	36.5	300	33.6	212	41.7
	1980–1994 (Generation Y)	603	43.0	435	48.7	168	33.0
	1995–2012 (Generation Z)	104	7.4	77	8.6	27	5.3
	2013–2025	2	.1	2	.2	6	1.2
	Prefer not to respond	25	1.8	25	1.8	96	18.9
Education	Postgraduate Degree Level	387	27.6	101	7.2	183	36.0
	Bachelor's degree Level	592	42.2	517	36.8	180	35.4
	Graduate Diploma and	136	9.7	549	39.1	44	8.6
	Graduate	145	10.3	173	12.3	60	11.8
	Certificate Level	106	7.6	33	2.4	28	5.5
	Secondary Education	8	.6	5	.4	1	.2
	Other and Prefer not to respond	29	2.1	25	1.8	13	2.6
Hours per week in work area	10 h or less	25	1.8	5	1.0	5	1.0
	11–30 h	101	7.2	70	13.8	70	13.8
	31–40 h	517	36.8	270	53.0	270	53.0
	41–50 h	549	39.1	131	25.7	131	25.7
	51–60 h	173	12.3	21	4.1	21	4.1
	More than 60 h	33	2.4	11	2.2	11	2.2
	Prefer not to respond	5	.4	1	.2	1	.2
Job type	Managers and administrators	396	28.2	272	30.4	124	24.4
	Professionals	672	47.9	367	41.1	305	59.9
	Tradespersons and related workers	8	.6	6	.7	2	.4
	Clerical	88	6.3	50	5.6	38	7.5
	Sales and service	124	8.8	110	12.3	14	2.8
	Other and Prefer not to respond	115	8.2	89	9.9	26	5.1
Type of employment	Full-time	1201	85.6	845	94.5	356	69.9
	Part-time	184	13.1	42	4.7	142	27.9
	Casual, Trainee, other and prefer not to respond	18	1.3	7	0.7	11	2.1

2.4. Analysis

To investigate the underlying structure of the questionnaire, Principal Component Analysis (PCA) was conducted on the dataset. In this statistical technique, the variables which are highly correlated are grouped together. Varimax rotation was used as the extraction method and variables with very weak correlations and/or communalities less than 0.5 were removed from the analysis [42]. The number of extracted dimensions is determined based on the Scree plot (eigenvalue>1). As presented in Table 3, 24 questions on a 7-point Likert scale were reduced to 4 independent variables.

To determine the best performing offices in the dataset, 4 factor scores (layout and interior design, IEQ, privacy and outdoor connection, and organizational aspects) were assigned to each office. These scores were calculated by averaging all questions contributing to that specific factor for each office. Offices were then ranked based on the scores they gained for each of these 4 factors. Five separate multiple linear regression tests were conducted to uncover the drivers of productivity, creativity, overall health, mental, and physical health in the top five high-performance workspaces identified from ranking the workspaces with 4 PCA factors. The perceived productivity question was different from the traditional productivity questions in the workspace research. For this question, on a 7-point Likert scale, the respondents stated their agreement/disagreement with the following statements: "all things considered the physical configuration of the workspace affects my productivity". Similarly, the creativity question asked "to what extent does the respondent agree/disagree that their workspace was conducive to creative thinking". Two similar questions were designed to capture respondents' mental and physical health over the past four weeks. On a 7-point Likert scale, the respondents were asked to "agree/disagree that their ability to work and/or develop work activities had been negatively affected because of their mental or physical health". These two questions were reverse coded for analysis. The question for overall health and

well-being also asked the respondents if they "agree/disagree that the physical configuration of the space affects their health and well-being". Measures of productivity, creativity, overall health were framed around the physical configuration of the space, however respondents' answer to the two questions on mental and physical health might reflect aspects beyond the physical space.

Since the top five high-performance offices in the dataset were all WELL certified, the differences between WELL and non-WELL offices regarding satisfaction and health were also investigated. First, the significant differences in mean values for satisfaction with the physical configuration of the space and organizational aspects were investigated through independent sample t-tests with homogeneity of variance not assumed. P-values lower than 0.05 were regarded as significant, however as the significance levels might be affected by the number of respondents, Cohen's d effect sizes (ES) were calculated to test the importance of these statistically significant differences. The Cohen's d effect sizes are categorized as small ($\geq$0.2), medium ($\geq$0.5) and large ($\geq$0.8) [43]. A medium or large effect size is more meaningful in the real world while a small ES shows an insubstantial mean difference. Second, percentage of satisfaction/dissatisfaction with the physical environment were represented by descriptive statistics, and the sources of dissatisfaction were investigated and compared. Finally, health-related aspects such as reported SBS and musculoskeletal discomfort were compared to identify any differences between WELL and non-WELL offices. All statistical analysis was conducted by IBM SPSS Statistics version 26. Nvivo 12 was used to extract the word clouds for open-ended comments.

3. Results and discussion

3.1. High-performance offices

The four components from PCA (Table 3) cumulatively can predict 67.2% of the variance in the data set (n = 1403). The contribution of

Table 3

Component loading for 24 survey questions reduced to 4 main factors.

Factors	Survey question description	Component loadings			
		PCA factor 1	PCA factor 2	PCA factor 3	PCA factor 4
Layout and interior design	Amount of personal storage available to you indoors	.779	.176	.102	.166
	Ability to adjust the surroundings/ equipment/ furniture to meet my needs	.777	.299	.202	.182
	Satisfaction with the furniture available to you indoors	.741	.321	.166	.228
	Amount of space available to you indoors	.700	.286	.113	.257
	Layout supports the way I work	.588	.281	.281	.315
	Workspace provides me with adequate visual privacy	.567	.051	.504	.099
	Satisfaction with office aesthetics	.515	.431	.375	.182
	Workspace adequately supports collaborative activities.	.494	.267	.401	.242
	Workspace aesthetics communicates the enterprise culture and values	.476	.401	.377	.247
IEQ	Indoor air quality indoors	.244	.865	.173	.140
	Satisfaction with air movement available to you indoors	.248	.850	.190	.108
	Satisfaction with humidity level indoors	.159	.838	.144	.110
	Satisfaction with temperature indoors	.185	.698	.186	.122
	Satisfaction with visual comfort	.281	.591	.237	.220
	Satisfaction with visual access to natural/sun light indoors	.283	.510	.243	.230
Privacy and outdoor connection	Satisfaction with acoustics indoors	.164	.352	.800	.173
	Satisfaction with acoustic privacy indoors	.151	.351	.799	.164
	Workspace provides me with zones that are free of distraction/ unwanted interruptions	.543	.120	.622	.102
	Workspace provides me with zones do develop focused work	.579	.231	.582	.120
	Physical configuration of the workspace enables connection between the indoor and outdoor environment	.362	.373	.407	.207
Organizational aspects	Organization promotes a positive work environment	.223	.168	.144	.847

Table 3 (*continued*)

Factors	Survey question description	Component loadings			
		PCA factor 1	PCA factor 2	PCA factor 3	PCA factor 4
	Organization promotes an inclusive culture.	.216	.133	.105	.831
	Feel motivated to come to work	.204	.116	.164	.797
	Organization's wellness policy	.122	.164	.077	.672

factor 1 (layout and interior design), factor 2 (IEQ), factor 3 (privacy and outdoor connection) and factor 4 (organizational aspects) to the variance were 47.7%, 8.1%, 6.9% and 4.5% respectively with "layout and interior design" having the highest contribution (47.7%), and organizational factors having the lowest contribution (4.5%). The relationship between the factors of high-performance workplaces and WELL features is demonstrated in Fig. 1.

The first two components explained around 56% of the variance in the dataset, with around 48% emerging from the first component. This component comprised nine aspects related to physical configuration of the space: 1) the amount of personal storage available to each worker in the office, 2) workers' ability to adjust the surroundings/equipment/ furniture to meet their needs, 3) general satisfaction with the indoor furniture, 4) amount of space available to the worker in the indoor environment, 5) indoor layout supporting the way the worker work, 6) visual privacy and 7) visual aesthetics in the workplace, 8) workplace being supportive of collaborative activities, and 9) workplace aesthetics communicating the enterprise culture and values. Component 2 featured traditional IEQ questions including satisfaction with indoor air quality, air movement, humidity, thermal comfort, visual comfort, and access to sunlight, except for acoustics. Component 3 constituted 5 questions, two of which related to acoustics (overall noise and acoustic privacy), two questions asked workers to what extent their workspace provides zones free of distraction/interruption, and to what extent their workspace provides zones to do focused work. It also included a question about satisfaction with the connection between the outdoor and indoor environment in the workspace. Finally, component 4, includes questions asking the workers if they agree that their organization promotes a positive work environment and inclusive culture, and if the worker feels motivated to come to work (engagement). It also includes a question which asks to what extent the worker is satisfied with the wellness policies (parental leave, sick leave etc.) in their organization.

When looking at studies in the literature which have performed PCA analysis, some similar and some slightly different results were reported. Veitch et al. [1] conducted a PCA analysis on 779 questionnaire responses from 9 offices in United States and Canada. With 18 questionnaire items they extracted 3 factors which predicted 57% of the variance in total. Conflicting, to some extent with our results, their first factor which included questions related to acoustics and privacy had a higher contribution to the variance compared to the second factor (ventilation and temperature). However, in our first component, a question related to visual privacy is also included which is similar to the visual privacy question in their first component. Veitch et al. (2007) [1] did not have any questionnaire items in relation to the physical configuration and interior design, so it is not possible to compare our PCA results against theirs in terms of layout and interior design. Supporting our results, Kent et al. (2021) [44] reported "privacy and space" as a factor that predicted around 50% of the variance in their dataset, followed by "cleanliness and maintenance". While our space and visual privacy questions were included in the first factor as for theirs, acoustic privacy and noise's contribution to the variance was lower in our study. It is worth noting that the concepts of layout and interior design may be more important and that is why the importance of "acoustic privacy and noise" has
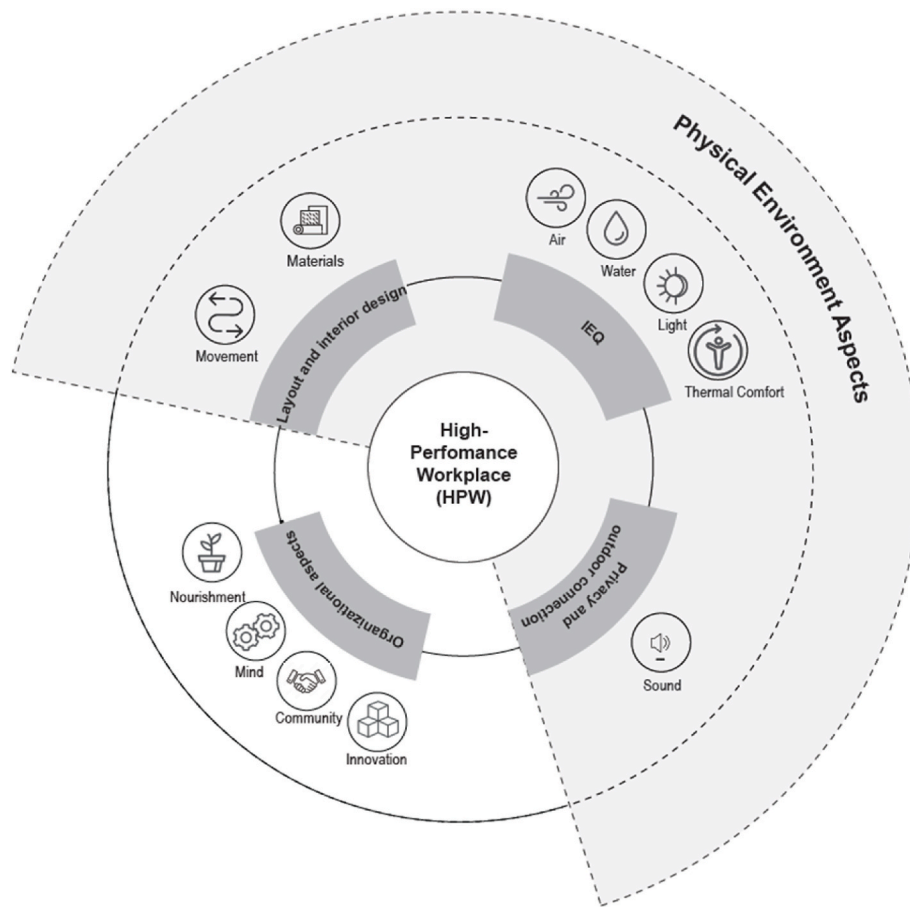
Fig. 1. Four high-performance workplace factors and WELL certified offices features (Source: Author).

decreased.

In the next step, the five high-performance offices were identified by ranking the mean scores of four factors determined from the PCA analysis. All 14 offices are ranked four times based on these 4 factors, and the same five offices were consistently at the top in slightly different orders. The mean values of these five offices were then compared against the mean value of the dataset as presented in Table 4. The mean values of the dataset were calculated considering the number of responses for each office. The values represented as "comparison with the dataset mean" were calculated by subtracting the dataset mean value from the office mean value. The positive values show that all five offices outperformed the dataset mean and they all hold a WELL certification.

In general, as shown in Table 4 for these five high-performance offices, there was 0.92–1.49 mean difference between the office mean and the dataset mean for factor 1 (layout and interior design), 0.89–1.20 mean difference for factor 2, 0.77–1.57 mean difference for factor 3, while the mean differences for factor 4 (organizational aspects) were lower (0.37–0.90) compared to the other three. The greatest difference

with the dataset mean value was seen in office 10 for privacy and outdoor connection (mean difference = 1.57) which included questions related to overall noise, acoustic privacy, distraction/interruption, concentration and connection to the outdoor environment. This finding highlights the well-known issues occupants have with noise and privacy [8,57], concentration [56] and outdoor connection [55] in standard open-plan offices. It emphasizes that design solutions for managing noise and privacy lie within the aspects that a high-performance open-plan office can be distinguished with. The smallest difference in mean values was seen in office 6 (mean difference = 0.37) for organizational aspects on a 7-point Likert scale. These aspects include positive work environment, inclusive culture, engagement, and access to wellness policies.

3.2. Drivers of productivity, health, and creativity for high-performance offices

To understand how the four factors related to the physical

Table 4
Mean scores for the database and the five high-performance offices.

Office	PCA factor 1 (Layout and interior design)		PCA factor 2 (IEQ)		PCA factor 3 (Privacy and outdoor connection)		PCA factor 4 (Organisational aspects)	
	Office mean	Comparison with the dataset mean	Office mean	Comparison with the dataset mean	Office mean	Comparison with the dataset mean	Office mean	Comparison with the dataset mean
11	6.07	+1.49	5.81	+1.20	5.34	+1.44	6.27	+0.90
2	5.75	+1.17	5.72	+1.11	4.67	+0.77	5.80	+0.44
6	5.64	+1.06	5.51	+0.89	5.35	+1.45	5.74	+0.37
10	5.59	+1.01	5.63	+1.02	5.46	+1.57	5.86	+0.50
12	5.50	+0.92	5.69	+1.08	5.12	+1.22	5.75	+0.38

environment, IEQ and organizational aspect had an impact on productivity, creativity, and health in high-performance workspaces, five separate multiple linear regressions were conducted. For each test, productivity, creativity, overall, mental and physical health were considered as the dependent variables with the four PCA factors (interior design, IEQ, privacy and organizational aspects) as independent variables. Table 5 summarizes the beta standardized coefficients and R^2 values for the regression tests.

"Acoustic privacy and connection to the outdoor environment" was the strongest predictor of productivity for high-performance offices (beta = 0.229) with "layout and interior design" as the second strong predictor (beta = 0.133), and IEQ and organizational aspects having a much weaker impact. For creativity, "layout and interior design" was the strongest predictor (beta = 0.219), with other three independent variables (IEQ, privacy and organizational aspects) having a very similar lower contributions with their beta values being similar (0.160, 0.150, and 0.17 respectively). "Acoustic privacy and connection to the outdoor environment" were the strongest predictor of overall health (beta = 0.327) with "layout and interior design" being second with beta value of 0.132. Interestingly, organizational aspects were the greatest predictor for mental health (beta = 0.313) while the other three independent variables (IEQ, privacy and layout) were much weaker in predicting mental health. Mental health status consists of aspects related to the workspace positive environment, inclusive culture, engagement, and wellness policies (e.g., parental leave and sick leave). For physical health, the two independent variables of IEQ and privacy had a similar beta value of 0.198 and 0.192 respectively, with organizational aspect (beta = 0.172) being the third predictor and "layout and interior design" (beta = 0.078) having a much weaker impact as the fourth predictor.

The importance of acoustics features (e.g., privacy and noise levels) and interior layout in open-plan offices and their effects on productivity and health has been emphasized by many studies. These studies reported that lack of perceived privacy, high levels of noise and lower acoustic satisfaction in general can lead to lower productivity and performance rates) [8,45–47]. Several studies also featured interior design as the strongest predictor for perceived productivity and health [6,24]. Similar to our study, Lin et al. (2021) [48] reported that when occupants perceived the physical work environment to be supportive in providing various workspaces, it is most likely to enhance creativity. De Paoli and Ropo (2017) [49] also mentioned aspects related to the spatial arrangement and connection to nature as important factors for designing a creative workspace.

3.3. Comparison between WELL-certified and non-WELL certified offices

As the top 5 high-performance offices were all WELL-certified, a question was raised: do WELL-certified offices outperform the non-WELL-certified offices in physical, environmental, organizational, and health-related aspects? A comparison with these two groups was conducted to answer this question. For physical and environmental aspects, layout and interior design, noise, and privacy, IEQ, thermal comfort and visual comfort, ergonomic fit and furniture, fixtures and ergonomics, and active design and physical activity were investigated. For organizational aspects, satisfaction with wellness policies, health promotion programs, inclusive culture, positive environment, and engagement were investigated. For health-related aspects, overall, mental and

physical health, sick building syndrome and musculoskeletal discomfort were considered in the WELL and non-WELL comparison.

3.3.1. Satisfaction with the physical environment (IEQ, layout, and interior design)

Table 6 shows the means and standard deviations of the aspects related to the physical environment for WELL and non-WELL offices. It also presents the comparison between the mean scores and their significance and effect sizes for these two groups. In general, satisfaction with 20 of 23 aspects related to the physical environment were significantly higher in WELL offices. However, the Cohen's D effect size for all variables was mostly small (0.2) with three factors (connection to the outdoor environment, access to sunlight and acoustics privacy, ES = 0.4) approaching a medium effect size. The greatest differences in mean scores were seen in satisfaction with connection to the outdoor environment (mean difference = 0.67), access to sunlight (mean difference = 0.62), and acoustics privacy (mean difference = 0.61). The smallest (non-significant) differences were seen in visual aesthetics, visual privacy, and furniture for which WELL offices showed very minor differences.

3.3.1.1. of satisfied and dissatisfied occupants.
Although the mean values for each questionnaire item gave a good understanding of the overall satisfaction scores, it did not accurately reveal the percentage of respondents who were satisfied/dissatisfied with each aspect related to physical configuration of the space. Fig. 2 represents the distribution of occupant satisfaction responses with the physical configuration of the space. The questions are asked on a 7-point Likert scale, ranging from "Extremely Dissatisfied" (1) to "Extremely Satisfied" (7) with a middle point of "Neither Satisfied or Dissatisfied" (4). To calculate the dissatisfaction percentages the number of respondents who answered 1 (Extremely Dissatisfied),2 (Dissatisfied) or 3 (Somewhat Dissatisfied) were summed and divided by total number of respondents in the sample. To calculate the satisfaction percentages, the number of respondents who answered 4 (Neither Satisfied or Dissatisfied), 5 (Somewhat Satisfied), 6 (Satisfied) or 7 (Extremely Satisfied) were summed and divided by total number of respondents in each sample (WELL or non-WELL). The respondents who answered 4 were calculated within the satisfied people as this answer was considered neutral and it was assumed that the respondents considered the situation acceptable when selecting this option.

As depicted in Fig. 2, in non-WELL offices, respondents were more dissatisfied with distraction/interruption (60%), acoustic privacy (57%), connection to outdoor (54%), visual privacy (49%), thermal comfort (47%), overall noise (46%) and concentration (46%). In WELL offices, these same seven aspects also had the highest dissatisfaction ratings although less respondents overall were dissatisfied in WELL compared to non-WELL offices. When digging deeper into satisfaction distributions for WELL offices, a majority of the features related to the physical environment had satisfaction rates lower than 80%, with only seven features having satisfaction percentages higher than 80%. These aspects were personal control (93%), active design (90%), amount of space (88%), layout (86%), light (84%), humidity (84%), and access to sunlight (80%). For non-WELL offices only three features had satisfaction rating higher than 80%: personal control (92%), active design (90%), and amount of space (80%). However, the top three aspects with

Table 5

Regression results with productivity, health and creativity as dependent variables, and four PCA factors as independents variables.

	Productivity		Creativity		Overall health		Mental health		Physical health	
	R2	Beta	R2	Beta	R2	Beta	R2	Beta	R2	Beta
Layout and interior design	0.06	0.133	0.14	0.219	0.11	0.132	0.11	0.036	0.12	0.078
IEQ		0.054		0.160		0.039		0.059		0.198
Privacy and outdoor connection		0.229		0.150		0.327		0.076		0.192
Organizational aspects		0.036		0.170		0.026		0.313		0.172

Table 6

Comparison (independent *t*-test results) between mean differences in WELL-certified and non-WELL certified offices.

	Satisfaction with …	WELL certified offices		Non-WELL certified offices		Mean difference[a]	Significance	Effect size (Cohen's D)
		Mean	Standard deviation	Mean	Standard deviation			
Layout and space	Layout (workspace supports the way I work)	5.16	1.42	4.72	1.65	0.43	0.00	0.29
	Concentration (zones for focused work)	4.12	1.74	3.90	1.70	0.23	0.02	0.15
	Visual aesthetics	4.35	1.73	4.33	1.68	0.02	Not significant	–
	Connection to the outdoor environment	4.05	1.70	3.38	1.85	0.67	0.00	0.44
	Collaboration (zones for collaborative activities)	4.71	1.50	4.54	1.55	0.17	0.04	0.11
	Aesthetics and Enterprise (the workspace aesthetics communicates the enterprise culture and values)	4.59	1.65	4.37	1.55	0.22	0.01	0.15
Acoustic comfort	Distraction/interruption (zones free of distractions)	3.74	1.78	3.36	1.77	0.38	0.00	0.25
	Overall noise	4.30	1.55	3.82	1.53	0.48	0.00	0.31
	Visual privacy	3.83	1.76	3.78	1.82	0.05	Not significant	–
	Acoustic privacy	4.14	1.61	3.54	1.62	0.61	0.00	0.40
IAQ, thermal and visual comfort	Indoor Air Quality	4.74	1.51	4.38	1.60	0.36	0.00	0.24
	Humidity	4.96	1.37	4.61	1.49	0.35	0.00	0.23
	Air movement	4.58	1.57	4.14	1.65	0.44	0.00	0.29
	Thermal comfort	4.36	1.61	3.95	1.62	0.41	0.00	0.27
	Light (including amount of light, reflections and contrast)	5.08	1.40	4.61	1.67	0.47	0.00	0.31
	Access to sunlight	4.91	1.52	4.29	1.97	0.62	0.00	0.41
	Personal control	5.41	1.23	5.84	1.27	−0.43	0.00	−0.29
Furniture, fixtures and ergonomics	Furniture	4.69	1.58	4.58	1.63	0.11	Not significant	–
	Ergonomic fit	4.59	1.57	4.29	1.68	0.30	0.00	0.2
	Amount of space	5.27	1.30	5.0	1.55	0.27	0.00	0.18
	Personal storage	4.60	1.71	4.71	1.72	−0.11	Not significant	–
Active design and physical activity	Ability to be physically active during the workday	4.54	1.48	4.28	1.47	0.26	0.00	0.17
	Active design (physical configuration of the workspace help you increasing your physical activity)	5.08	1.26	4.70	1.41	0.38	0.00	0.25

Note: The questionnaire items are grouped together for the clarity of the arguments, not as factors emerging from factor analysis.

[a] Mean differences were calculated by subtracting the mean satisfaction scores of non-WELL workspaces from WELL-certified workspaces.

the highest satisfaction ratings were consistent between WELL and non-WELL offices: personal control, active design and amount of space.

The greatest differences in satisfaction distributions between WELL and non-WELL offices were seen in access to sunlight, acoustics privacy, and connection to the outdoor environment, with all the features having 17% higher satisfaction in WELL offices. The only feature in which non-WELL offices recorded higher number of satisfied respondents was personal storage (2% difference), noting that there is no feature in WELL Building Standard which directly promotes the provision of personal storage for the workers. A study by Candido et al. (2021b) [24] also showed that average scores for connection to the outdoor environment displayed the biggest differences for occupants' satisfaction when comparing WELL and non-WELL offices.

The satisfaction ratings in this study are consistent with a study by Karmann et al. (2017) [50] which found that sound privacy, noise, visual privacy, temperature, and visual comfort had the highest proportion of dissatisfied occupants in the studied dataset. Similarly, Cheung et al. (2021) [7] reported 42% dissatisfaction with sound privacy, 30% for air temperature, 26% for overall privacy, and 21% for noise levels. The same study also reported 32% dissatisfaction with the personal control, one of the aspects in the indoor environment with the highest dissatisfaction rate, however in our study only 7% (WELL) and 8% (non-WELL) respondents were dissatisfied with personal control.

Studies have consistently shown that it is difficult to demonstrate high levels of satisfaction rates for IEQ aspects such as thermal comfort, noise, acoustics and visual privacy in open-plan workspaces with different settings [6,7,14,17]. Our study results highlight that although occupants in WELL-certified offices showed lower rates for

dissatisfaction with these aspects of the physical environment, they still had the highest dissatisfaction rates compared to non-WELL offices. This raises the question that why a significant portion of the occupants are always dissatisfied with IEQ in open-plan offices regardless of the physical configuration of the space, and if achieving high satisfaction rates for some of the IEQ aspects such as thermal comfort, noise, acoustics and visual privacy is even possible. The dissatisfaction might partially originate from the expectation that all work activities can be performed from the same location within an open-plan office, however research showed that various work activities necessitate different work settings and design (e.g., noise levels, lighting, furniture, privacy and the overall design). When the occupant does not have the opportunity to move around based on the task at hand and their preference, the well-known chronic issues around noise, thermal comfort and privacy are inevitable. On the other hand, lack of personal control over the environmental conditions and the fact that majority of open-plan offices are fully air-conditioned with very limited or no access to change temperature, air movement or humidity help explain high dissatisfaction rate with thermal comfort.

3.3.1.2. Sources of dissatisfaction with IEQ and office layout. In the WELL Building Standard there are specific features related to acoustics, thermal comfort, lighting, and air, and a workspace which each need to be ticked off as pre-conditions to be awarded the lowest level of certification. The question which asks about the reason for dissatisfaction in our survey was not aligned with any specific features in WELL Building Standard, however the question choices such as lack of access to daylight, insufficient spaces for private conversations, and insufficient
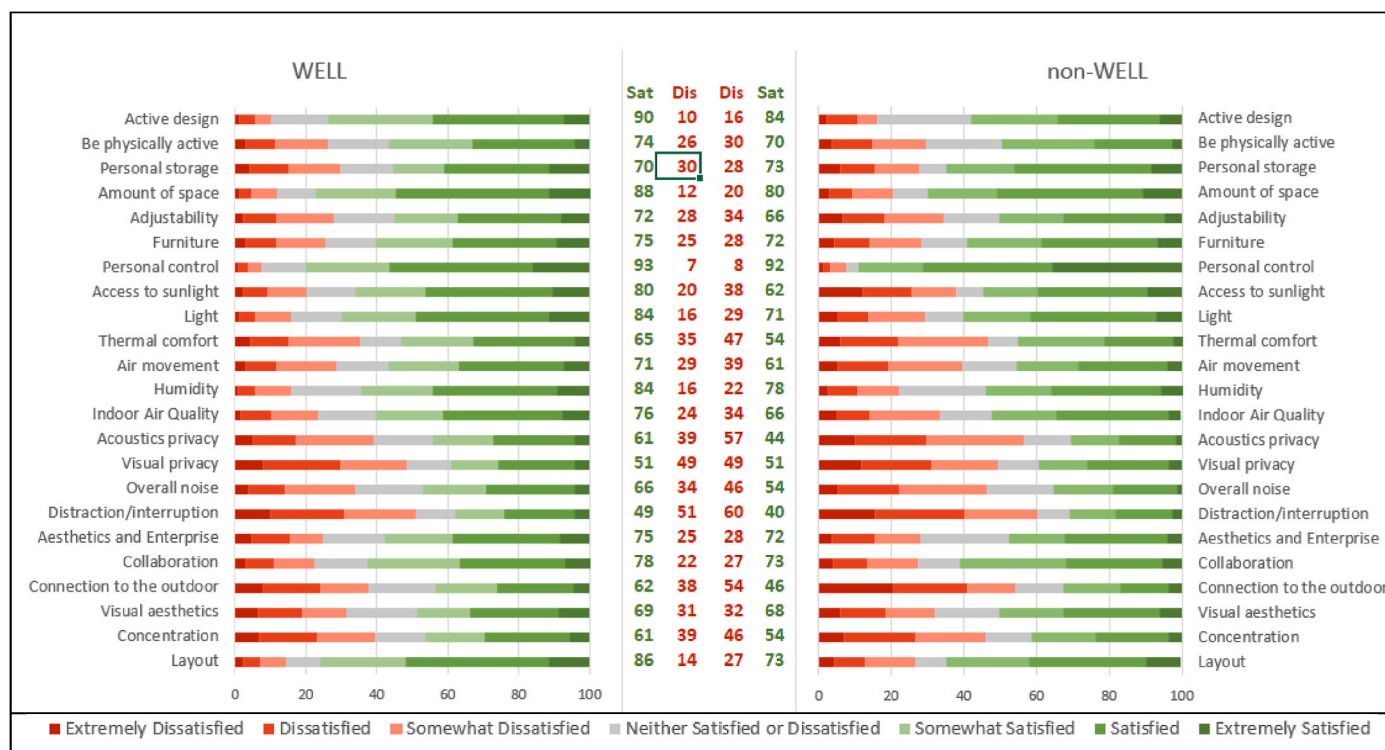
Fig. 2. Distribution of occupant satisfaction/dissatisfaction with aspects related to physical configuration of the space, and the percentage of satisfied and dissatisfied respondents in regard to each aspect (questionnaire item) ("Sat" shows the satisfaction distribution (%) and "Dis" shows the dissatisfaction distribution (%)).

break-out spaces are addressed in light, sound and mind features of WELL Building Standard respectively.

The sources of dissatisfaction with acoustics, thermal comfort, air, light and layout are depicted in Fig. 3 for both WELL and non-WELL offices. These questions appear as follow-up only if the respondent has indicated their dissatisfaction with a specific aspect of the physical environment by selecting option 1 to 3 (Extremely Dissatisfied, Dissatisfied or Somewhat Dissatisfied). The respondents can select multiple options as the reasons for their dissatisfaction. The percentage for each option was calculated in relation to the number of respondents who indicated their dissatisfaction in that specific question.

For thermal comfort, overall, 35% of respondents in WELL and 47% of people in non-WELL offices reported dissatisfaction. For both groups, being "too cold" and "too hot" were respectively reported by around 70% and 40% of all respondents. However, it should be noted that the data collection for this research was conducted over a 16-month period, meaning that the respondents may have answered the questionnaires in different seasons. It was not possible to pinpoint the dissatisfaction reasons with the season or outdoor weather, however it was likely that the overcooling in these air-conditioned workspaces had happened. The overcooling issue reported in this study is consistent with the study by Cheung et al. (2021) [7] which reported overcooling in some of their studied workspaces. Another study by Sekhar et al. (2003) [51] also showed that the air-conditioned commercial buildings were overcooled. Local discomfort (feeling too hot/cold in neck, hands or ankles) was also raised as the third source of dissatisfaction with temperature by 17% of the dissatisfied respondents in non-WELL and 14% in WELL offices in our study. These findings raise the question of whether temperature setpoints are appropriate for air-conditioned commercial spaces, considering that they follow the approved set points range in the relevant building codes and guidelines.

For air quality, the two main sources of dissatisfaction were "not enough air movement" and "stuffy" reported by 54–61% of the occupants in WELL and non-WELL offices. For lighting "glare from light", "too bright" and "too dim" were reported as main sources of lighting

dissatisfaction for both WELL and non-WELL offices. "Noise from people" is indicated as the most important reason by 92–93% of the dissatisfied respondents for both groups, followed by not having a private place for phone calls (59% WELL, 44% non-WELL), private conversations (41% WELL, 35% non-WELL) and teleconferencing (36% WELL, 26% non-WELL). Interestingly for each of these latter three noise related features (a private place for phone calls, private conversations and teleconferencing), the non-WELL offices performed better compared to WELL offices. On the contrary, in regard to noise from phone ringing, air conditioning and construction, WELL offices outperformed the non-WELL offices due to lower number of dissatisfied respondents.

For layout and interior design, respondents in non-WELL offices indicated lower satisfaction with "lack of access to daylight", "lack of access to plants and greenery", and "insufficient number of desks". This result was consistent with section 3.1.1 which indicated the greatest differences in satisfaction distributions between WELL and non-WELL offices were seen in access to sunlight and connection to the outdoor environment. There was also a 14% difference in the proportion of dissatisfied respondents selecting "insufficient spaces assigned for concentration" as the source of dissatisfaction for layout, with non-WELL offices outperforming WELL offices. These findings emphasize the importance of physical configuration of the space and interior design in predicting occupants' satisfaction with the workspace. When a space is not well-designed to cater for a range of different activities such as concentration, collaboration, having a private conversation and having a break, occupants report higher levels of dissatisfaction. Although the literature on dissatisfaction scores and their sources in regard to different aspects of the physical environment is limited for WELL-certified workspace, it is clear that these workspaces are also experiencing many of the same issues as reported in open-plan offices.

3.3.2. Satisfaction with organizational aspects

Since the International WELL Building Institute has set their main aim to advance human health not only through design intervention and operational policies but also through organizational policies and a
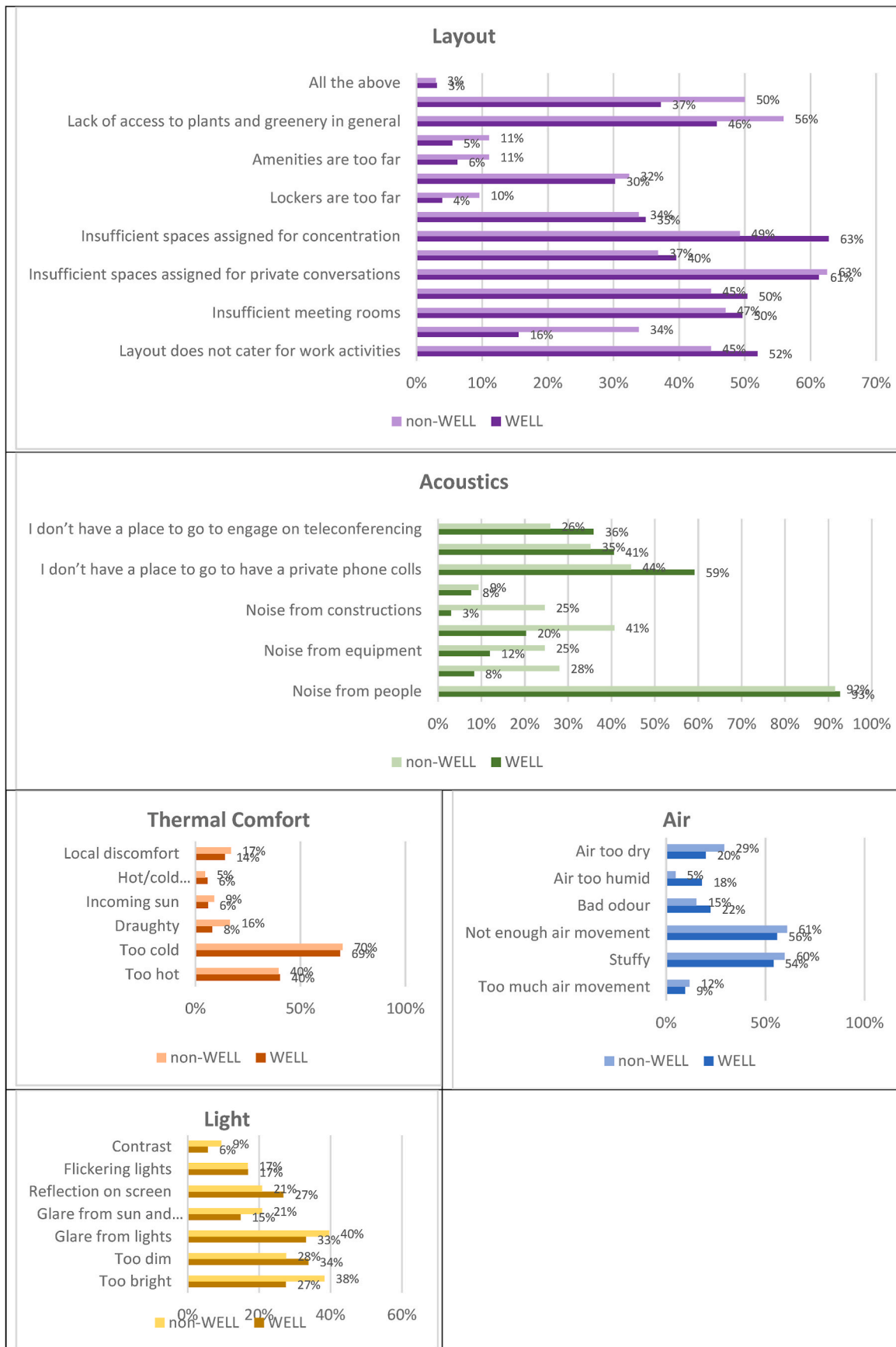
Fig. 3. Sources of dissatisfaction with light, acoustics, air, thermal comfort and layout for WELL and non-WELL offices.

culture of health (specifically in the Community concept, Mind feature), this section looks at organizational aspects in WELL and non-WELL offices. When investigating the differences in organizational aspects in the Community feature of the WELL Building Standard (Fig. 4), significant differences ($p < 0.05$) favouring WELL offices were found for 'inclusive culture' (mean difference = 0.3), 'health promotion programs' (mean difference = 0.3), 'positive environment' (mean difference = 0.6), and 'engagement' (mean difference = 0.3). In contrast, non-significant mean differences were seen for 'wellness policies' (e.g., parental leave and sick leave). The greatest mean difference was seen in the 'positive environment' (mean difference = 0.6 on a 7-point Likert scale) with WELL certified offices performing better. In general, there was slight differences in WELL and non-WELL workspaces regarding organizational aspects with WELL offices outperforming non-WELL offices.

Word clouds in Fig. 4 illustrate the most frequents words mentioned in 77 open-ended comments in relation to the organizational aspects for WELL offices. Words and topics such as work (count = 14), wellness (count = 14), policy (count = 10), team (count = 7), health (count = 6), culture (count = 5), flexible (count = 5), leave (count = 4) were stated in the open-ended comments. As can be seen in Table 7, although WELL offices are ranked higher, both positive and negative comments are mentioned by office workers in WELL offices addressing wellness, health, culture, flexible working and leave entitlement.

3.3.3. Health, sick building syndrome and musculoskeletal discomfort

Since WELL Building Standard is claimed to be a vehicle to enhance human health and well-being, we investigated if WELL offices outperformed non-WELL offices in health-related aspects. When looking at the question of 'overall health', the mean scores were slightly higher in WELL offices (mean difference = 0.15, $p > 0.05$), however this difference was not statistically significant. Non-significant differences were also seen for questions related to mental and physical health; however, it should be noted that the answers to these questions may be affected by many other factors unrelated to the workspace. Both questions are framed to capture if the respondent's ability to work and/or develop other activities has been negatively affected because of their mental and emotional health, or physical health.

As two proxies for health, reported Sick Building Syndrome (SBS)

Table 7
Examples of open-ended comments related to organizational aspects in WELL offices.

Frequent word in the open-ended comments	Respondent's comment
Wellness	Denied 1-week parental during COVID-19 forced to use annual leave. 'Self-service' wellness modules garbage.
	We have a great wellness team who are always trying to promote healthy stuff.
Culture	Positive, enabling culture driving good engagement. High trust environment.
	Trying but not embedded in the culture, yet.
Flexible	Flexible working is practically non-existent in my dept and is frowned upon by management
	Flexible working policy is great. Support for home needs is great e.g., pickups/kids etc.
Health	Love the health and wellness programs and initiatives. Especially the fruits!
	Meetings and "health initiatives" during lunchtime is a terrible idea and runs counter to "healthy".
Leave	I am disappointed with the fact that we don't have paid maternity leave. It gets difficult.
	Leave policy is an Australian issue, far too few days available compared to other nations.

symptoms and reported musculoskeletal discomfort were considered and are depicted in Fig. 5. In general, the percentage of occupants who reported SBS symptoms was 12% higher in non-WELL offices, and similarly for all symptom categories non-WELL occupants reported more complaints as also reported by McNaughton et al. (2017) [31]. Headache was the most frequent SBS complaints for both officse groups (WELL 31% and non-WELL 42%), with allergy-like symptoms (e.g., sneezing) being the second most frequent reported symptom (WELL 17% and non-WELL 25%). Dry and itchy skin, runny nose and throat irritation were reported by 8–14% of the occupants in both office groups.

The percentage of occupants who reported musculoskeletal discomfort was 6% higher in non-WELL offices (WELL 30% and non-WELL 24%). For all body areas (e.g., feet and ankle, legs, lower back, upper back, shoulders and neck), the percentage of occupants who reported the discomfort was slightly higher in non-WELL office. Consistent
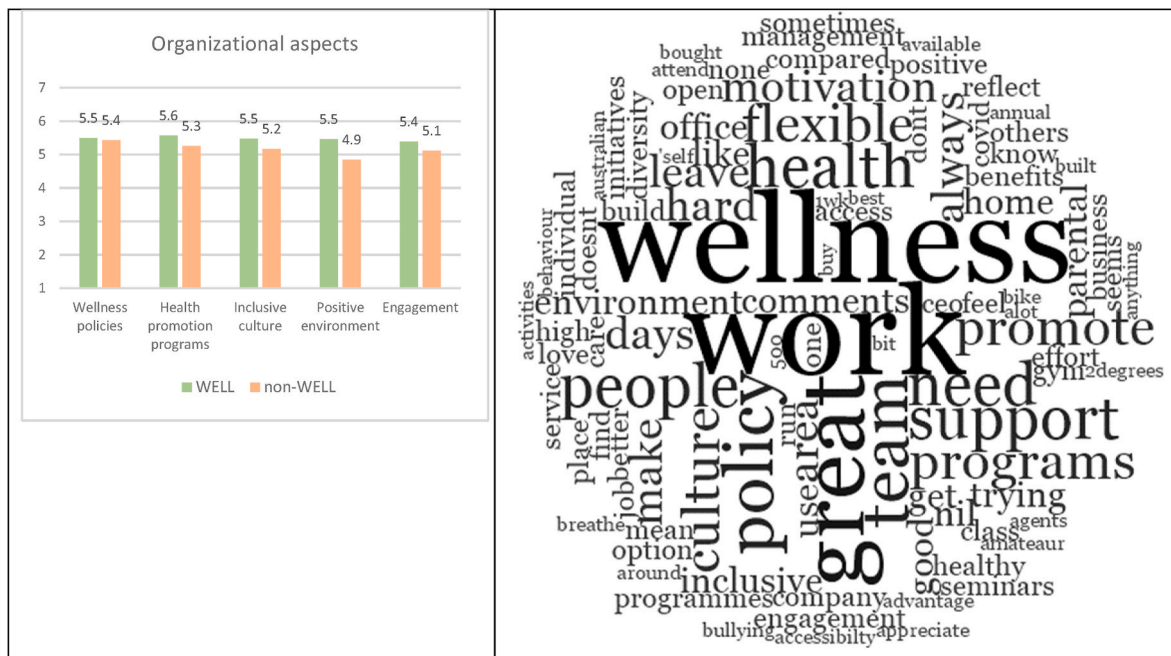
Fig. 4. Mean values for organizational aspects in WELL and non-WELL offices (p-value<0.05 for all aspect except wellness policies) (Left), and word clouds for open-ended comments for organizational aspects (right).
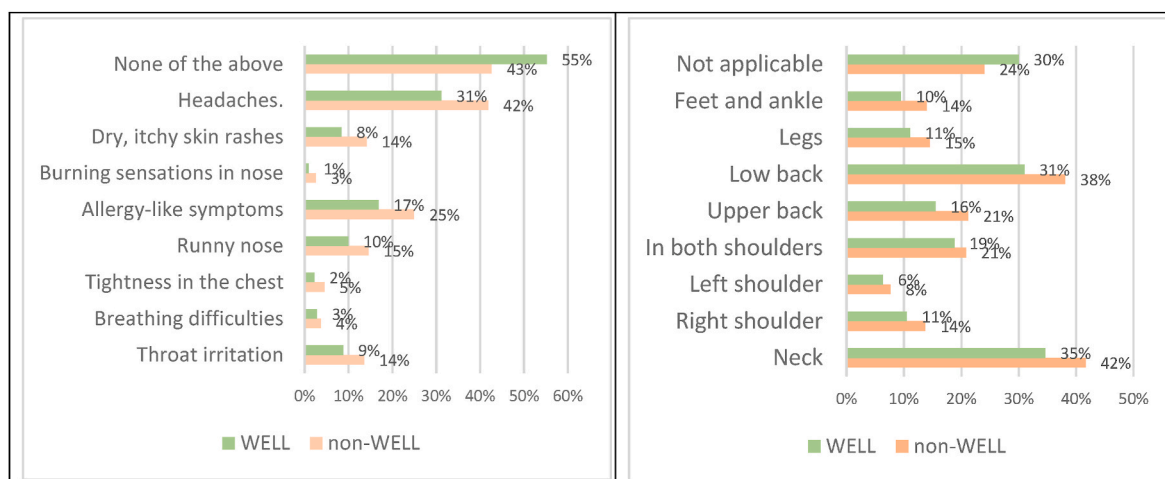
Fig. 5. Reported Sick Building Syndrome symptoms (Left), and reported musculoskeletal discomfort in WELL and non-WELL offices (Right).

with findings from several other studies [28,52–54], the most frequently reported body areas for pain/discomfort were lower back (WELL 31% and non-WELL 38%) and neck (WELL 35% and non-WELL 42%). Discomfort/pain in feet and ankle, legs, upper back and both shoulders were reported by 10–19% of occupants in WELL offices and 14–21% of occupants in non-WELL offices.

4. Conclusion

This study investigated the drivers of occupants' productivity, creativity, and health in high-performance workplaces, and explored the differences between WELL-certified and non-WELL-certified workplaces in regards to occupants' satisfaction and perceived health. Four factors of interior design, IEQ, privacy and connection to the outdoor environment, and organizational aspects have emerged from our SHE survey questionnaire as the underlying structure of the SHE survey. "Privacy and outdoor connection" was the key predictor for productivity, 'layout and interior design' for creativity, 'organizational aspects' for mental health, 'privacy and IEQ' for physical health, and 'privacy' and 'outdoor connection' for overall health.

Our findings show that benefits related to satisfaction, health, productivity, and creativity may be achieved by following the WELL building standard. In our dataset, satisfaction with the physical configuration of the space was higher in WELL-certified offices compared to non-WELL-certified offices in majority of the features. Regardless of being WELL or non-WELL, in most categories related to the physical environment, there were more than 20% dissatisfied respondents. The average scores for IEQ aspects such as thermal comfort, noise, visual and acoustic privacy were low. The consistent interior design issues reported in open-plan offices, such as not having a space for private conversations or concentration even in high-performance workspace raises the question whether is it even possible to achieve high levels of satisfaction in the interior design aspects?

When occupants were dissatisfied with different aspects of the physical environment, their reasons for dissatisfaction were consistent between WELL and non-WELL offices in respect to thermal comfort, air quality and lighting. For noise and layout, differences were seen in sources of dissatisfaction. For some aspects WELL offices outperformed the non-WELL offices and for other aspects the reverse was found. Satisfaction with most organizational aspects was higher in WELL offices. There was no significant difference in overall, mental and physical health reported from workers in WELL and non-WELL offices, however fewer complaints related to SBS and musculoskeletal discomfort were reported in WELL offices. These outcomes may be partially explained by other factors, but the findings suggest that there are meaningful differences in workspaces that pursued WELL certification.

Occupants in WELL offices showed higher level of satisfaction in general with lower number of complaints for SBS and musculoskeletal discomfort. However, the consistent issues in almost all offices emphasize the importance of physical configuration of the space and interior design in predicting occupants' satisfaction with the workspace. When a space is not well-designed to cater for a range of different activities such as concentration, collaboration, having a private conversation and having a break, occupants report higher levels of dissatisfaction. Our results showed that there are still some issues and weaknesses with the high-performance open-plan offices in this study.

Currently with "return to office" emerging scenarios as the pandemic is more under control, questions are raised about the effectiveness of open-plan offices in the new era. As a response to the new situation with fear of transmitting diseases and greater expectations to work from home, many workplaces have introduced office layout changes including buffer zones and plastic screens intended to reduce the risk of viral transmission, and implemented new flexible work arrangements. For many organizations this new way of working strategy will mean more teamwork and collaboration happening in the head office and more focused work away from the office. However, this strategy might also increase dissatisfaction with the acoustics previously reported in open-plan offices thus hampering productivity and stress.

Although there is a deep gap between managers' expectations and employees' expectations about how the work from home scenario might be implemented, it is expected that this new work arrangement will fixate the notion of "work is something we do, not a place we go to". Hence organizations might think of methods to enhance productivity and quality of work away from the office. This means aspects that are discussed in this study such as wellness, culture, engagement, and leave policies are even more important in the post-COVID world.

5. Limitations

This study provides a snapshot of occupants' satisfaction, productivity, creativity and health from a dataset of 1403 responses collected from 14 offices. The dataset used for analysis only includes subjective survey, with no objective measurements. Although we looked at the drivers of satisfaction, productivity and health for the dataset, we acknowledge that these variables might be affected by many factors beyond the workspace which are not in the scope of this study. We also acknowledge the limitation of a small sample size of 14 offices in this study.

CRediT authorship contribution statement

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Samin Marzban reports financial support was provided by Australian Research Council. Christhina Candido reports financial support was provided by Australian Research Council. Behnaz Avazpour reports financial support was provided by Australian Research Council.

Data availability

The data that has been used is confidential.

Acknowledgements

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