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Design workplaces to support employees, organizations, and the environment: The triple bottom line

Jennifer A. Veitch, Sepideh Masoudinejad, Natalia Cooper,
Alexandra Thompson, and Guy R. Newsham

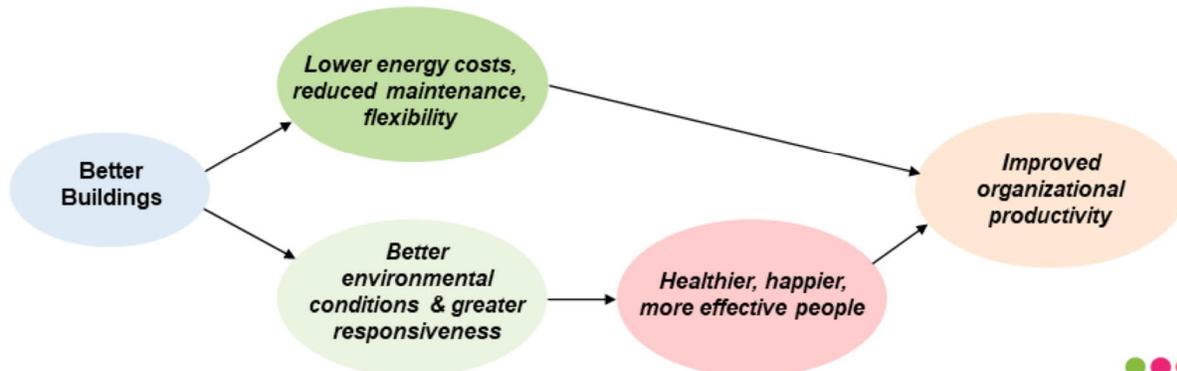
2021-06-20, EDRA 52 – Work Environments Networks

The global pandemic of COVID-19, according to some commentators, changes everything: Remote work forever! The death of the office! Reshape our cities! End commuting! There is no question that in the short term, many of these forces are at play; but this might not be the right set of choices for the long term. Trust, social cohesion, informal communication, and idea generation all benefit from co-location and shared experience. Many organizations will find that a physical location remains necessary. The current times do reveal the need to decrease occupant density, provide more separation between individuals, and to change building ventilation strategies to prevent disease transmission. These run counter to recent design trends and to many organizations' and governments' strategies to address facilities costs and reduced greenhouse gas (GHG) emissions associated with those facilities. Our group has long argued that workplace design and building operation needs to support the needs of employees, organizations, and the environment. This means that efforts to address environmental goals such as reducing GHG emissions and achieving sustainable construction ought not to come at the expense of organizational productivity understood broadly, taking into account not only the quantity of work produced or the value of products sold, but also individuals' job satisfaction, organizational commitment, intent to turnover, absenteeism, and overall well-being. This presentation will blend results from several streams of recent NRC research, addressing the relationships between organizational productivity and activity-based working; satisfying individuals' needs for various building amenities; and interior environmental conditions. In parallel, our colleagues have demonstrated that connected building operations can rapidly pay back in reduced energy use, which may be the smart route to take to achieve the indoor environmental conditions in buildings that individuals need and for organizations to prosper while delivering on society's environmental and climate-change targets.

NRC's Better Buildings approach

Similar to the “multiple benefits” approach in energy-efficiency circles

The right investments are those that contribute to **Environmental**, **Social**, and **Corporate Governance** (ESG) goals.



Our goal is to use changes to buildings to contribute positively to organizations in three senses: planet (environment), people (social), and profit (corporate governance). This is very possible but needs careful attention to avoid unintended consequences.

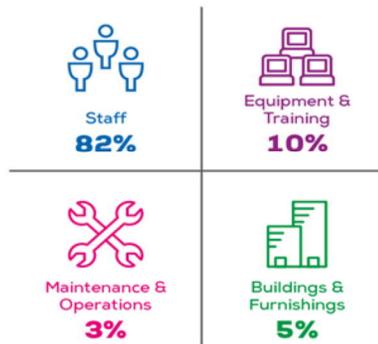
We could use knowledge about specific technologies and conditions to calculate KPIs (and I will talk about some), but there's a moral imperative there too. There are short-term choices that can be made that will give the appearance of success at the cost of employee outcomes. It takes nuance to pay attention to the people side.

Shift the focus from costs alone ...

Think strategically to support employees, avoid environmental waste, and improve organizational productivity

Another common rubric is

- \$300 /sf for people
- \$30 /sf for operating expenses
- \$3 /sf for capital costs



Brill, Weidemann, & BOSTI Associates, 2001.

This is a widely-cited breakdown of the costs associated with office workplace costs over a 10-year period (Brill, Weidemann, & BOSTI Associates, 2001). Another common rule of thumb is that the annual operational costs of an office space are, on average \$300/ft² for staff payroll, \$30/ft² for space rent, and \$3/ft² for utilities (Best, 2014). Thus, one would not want cost savings in buildings to come at the expense of staff's ability to do their work. Ideally an organization would identify building strategies that support the productivity of the organization, and are cost-effective as a whole. In other words, a relatively small investment in building design and operation can have a relatively big benefit on organizational productivity through positive effects on staff (and energy use).

This argument based mostly on costs has been around for at least 40 years (since the original BOSTI work in the 1980s), but I am not convinced that it has been fully appreciated given the popularity of very-high-density bench-seating designs.

Consider the whole picture

Output \$ / Input \$

Multiple KPIs on both sides of the equation



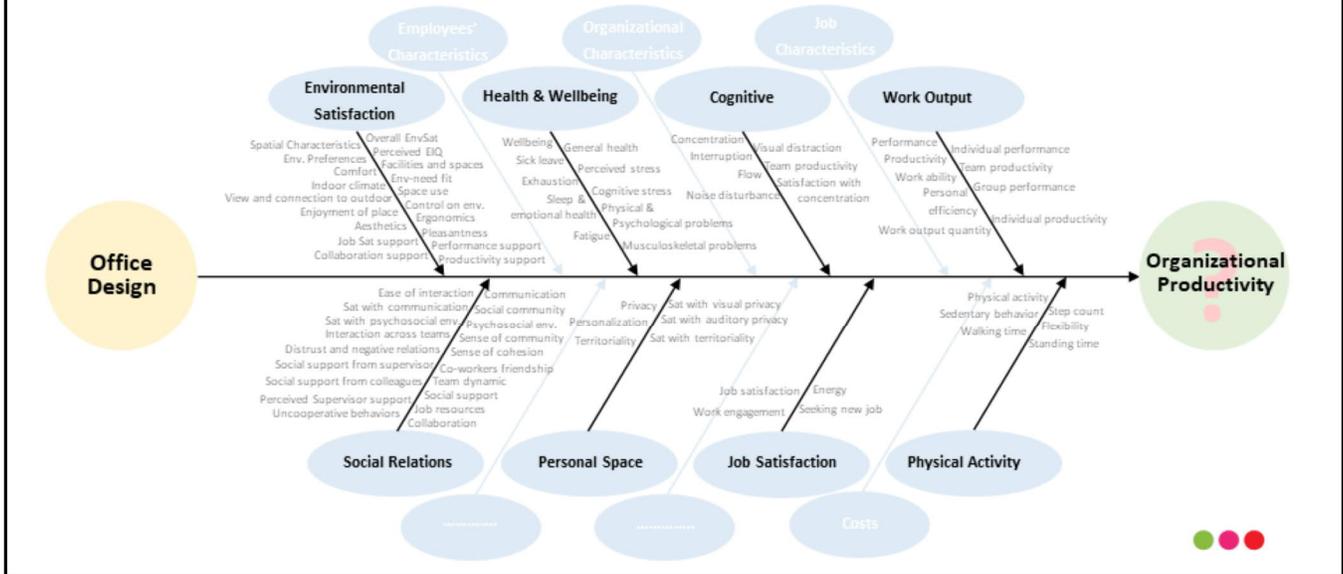
Building features can affect both input costs and output values. Poor indoor air quality could result in increased illness absence (a cost). Employees who are not ill might have increased workloads to compensate for absent colleagues, and this could in turn result in lowered output quality (reduced output value). This is a more complex and nuanced approach than the simple industrial relationship, but offers a pathway to move forward in this domain that an overly simple metric does not offer.

Oseland and Burton (2012) noted that while most researchers acknowledge that there is an under-appreciated relationship between office design and environmental conditions and (organizational) productivity, the fact that it is difficult to quantify means that it is. The only metric typically used in relation to the workplace has been size, which has led to strategies that promote density, and thus a saving on the one metric used, rather than the well-being and performance of those inhabiting the space. Indeed, Oseland and Burton (2012) found that "... only one in eight organizations had productivity metrics in place and none monitored the relationship between the environmental conditions and business performance." Lacking metrics in this domain, organizations tend to focus on the real-estate costs of space, which are easily measured and monetized.

This is exacerbated by the classic split incentive problem, facilities management typically reports to the CFO/COO, with a motivation to cut costs, rather than to an executive with a responsibility for employee well-being or workflow optimization (The Stoddart Review, 2016).

A7 ESG goals and how bldg and people contribute to them
Author, 2021-05-04

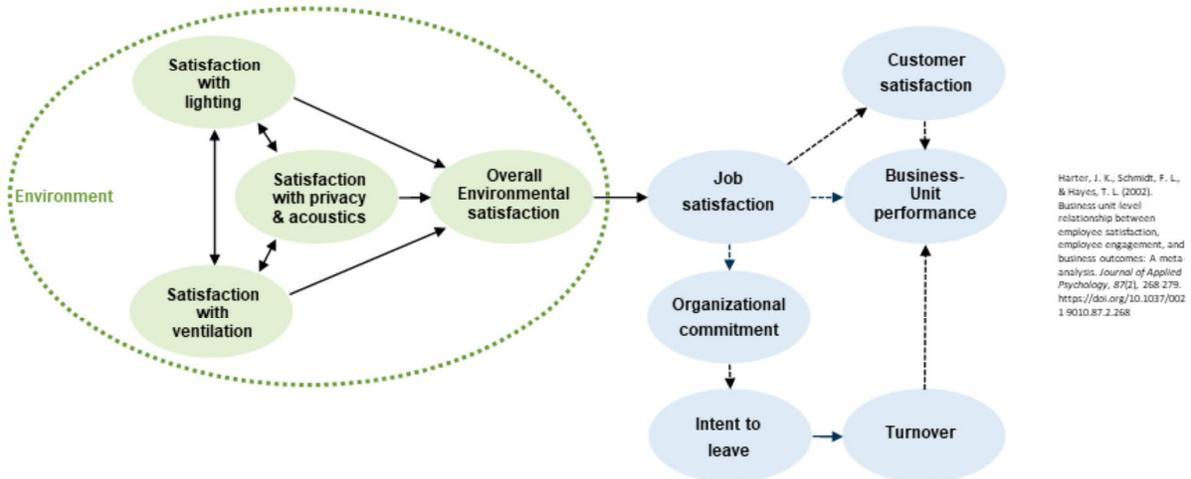
Studying the people in the equation



We've been doing some literature reviews lately, and these are among the outcomes that we have found in various investigations. We've been working to group them to come to some general conclusions and, where possible, to build multivariate models that can establish how these concepts contribute to overall organizational productivity and the ESG goals. I have a few examples coming up.

The important point here is that we need to look comprehensively at the effects on the people to have a clear understanding of the effects on organizations - -but as the next slide will see, even the employee effects are not the entire picture.

A partially integrated model



Veitch, J.A., Charles, K.E., & Newsham, G.R. (2004). *Workstation design for the open-plan office* (ConstructionTechnology Update No. 61). Ottawa, ON: National Research Council Canada, Institute for Research in Construction.

We can begin to develop a model of how the physical environment can affect employees attitudes and behaviours, which in turn can influence organizational success, by combining our thinking with other research. . This model shows the relationships we found in the COPE study (in bold), and those from some of the other research examples given here (dotted).

Note that to get a full understanding of the organizational productivity model, one needs to also look beyond employees, to measures like customer satisfaction and business unit performance. (Note that business unit performance itself has measurement challenges, especially in the public sector. That gets into a separate discussion about organizational effectiveness measures.) Together with the environmental performance measures (like energy use intensity) one can move towards a full understanding of the achievement of ESG goals.

This model is only a partial model, not all the possible variables have been shown, and there are still many places where there are research gaps. However, you can see that we can begin to build a coherent picture that supports the importance of the physical environment.

You can see from this model that to positively influence organizational success, we need to positively influence employees' attitudes and behaviours (like commitment and satisfaction). We know from our own studies that we can influence job satisfaction by increasing environmental satisfaction.

How do we influence environmental satisfaction?

Surveys show...

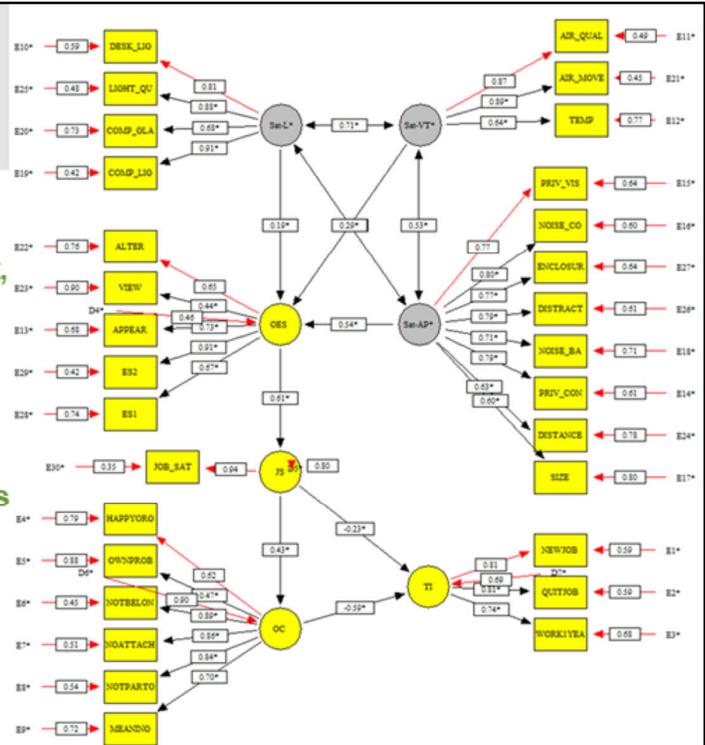
When people are satisfied with the elements of the physical environment,

they are happier with the overall environment (OES)...

and with their jobs (JS)... more committed to their organizations (OC) and

less likely to intend to look for a new job (TI)

(Cooper & Veitch, in preparation)



This structural equation model is one we have developed and replicated based on data several cross-sectional field investigations. Some of the people occupied buildings with Green certification and others worked in unrenovated buildings. The model is robust, but what is not perfectly known yet is which environmental conditions will lead people to be most satisfied.

Overall...

These are sample results from a real NRC investigation of a lighting retrofit, with extrapolation for the business unit performance.

NRC Better Buildings Scorecard			Building 1	Building 1	Building 2	Building 2
	Units	Target	(post-reno)	(pre-reno)	(no reno)	(no reno)
			2019_Q4	2018_Q4	2019_Q4	2018_Q4
Overall Environmental Satisfaction	1-7	> 4.2	4.9	4.1	4.3	4.2
... with Lighting	1-7	> 4.9	5.3	4.5	4.6	4.6
... with Ventilation & IAQ	1-7	> 4.2	4.6	3.9	3.9	3.6
... with Privacy and Acoustics	1-7	> 4.1	4.0	3.2	3.1	3.0
Job Satisfaction	1-7		5.2	4.5	4.5	4.6
Well-being						
Physical symptoms	0-16	< 2.5	1.6	2.2	2.2	2.3
Mood	1-9	> 5.5	5.9	5.2	5.1	5.0
Absenteeism	days/person/month	< 0.6	0.5	1.0	1.1	0.9
Staff Commitment						
Organizational Commitment	1-7	> 4.0	5.1	4.6	4.8	4.7
Intent to Turnover	1-7	< 2.4	2.3	2.7	2.7	2.6
Business Unit Performance						
Customer Satisfaction extrapolated	% satisfied	1-4% inc.	87	84.5	84.5	84
Profitability extrapolated	% profit of sales	1-4 % inc.	12.2	11	11	10.5
Environmental Conditions						
particulate count PM _{2.5}	µg/ m ³	15				
CO ₂ concentration	ppm	<625				
Predicted Mean Vote (thermal comfort)	-3 to +3	0				
Light level on desks	lx	300-500	490	290	310	325
Speech intelligibility index	SII	< 0.20	0.39	0.40	0.42	0.45
Energy Use Intensity						
Lighting	kWh/m ² /day		0.14	0.39	0.42	0.42
Heating and Ventilation	kWh/m ² /day		2.3	2.2	2.0	2.1
Responsiveness						
Number of complaints	#/month	2				
Average response time	days	2				

The project in which we obtained these data is one of the ones in the Better Buildings column of the review paper (next slide). The renovation involved new lighting and new furnishings, including a change to the lighting equipment and introduction of individual controls that resulted in a large overall drop in lighting energy use. A prior investigation on this point had convinced the organization to roll out the lighting change throughout its offices.

You can see that the energy use intensity for lighting dropped a lot, but overall EIU for these buildings stays high because of heating and ventilating needs. However, we see that the benefits to satisfaction translate into good overall results for the organization, and these outweigh the investment cost of the lighting equipment.

We can be confident that the renovation caused the changes because we see that there were no changes in a companion building over the same time period.

These data (times and exact numbers) have been massaged for anonymity, but the effect sizes and trends are accurate. There were no data for the air quality or Responsiveness KPIs.

Better Buildings stack up

Newsham, G. R., Veitch, J. A., Zhang, M. Q., & Galasiu, A. D. (2019). Comparing better building design and operation to other corporate strategies for improving organizational productivity: A review and synthesis. *Intelligent Buildings International*, in press. <https://doi.org/10.1080/17508975.2019.1588700>

	Strategies (IV)→	Better Buildings	Office Layout (Cell-Open)	Workplace Health Programs	Bonuses	Flexible Work Options	
Benchmark ↓	Metrics or KPIs (DV)↓						Unit ↓
2 – 15	Absenteeism	↓ 0.4 – 1.5	↑ 3.2	↓ 0 – 1.8	↓ 1.0	↕	day/per/yr
18 – 30	Employee Turnover (int.)	↓ 1.3	↑ 18	0	↓		0 – 100
0	Self-assessed Performance	↑ 2 – 10	↓ 8– 15	↑ 0 – 10	↑		%
60 – 80	Job Satisfaction	↑ 4 – 9	↓ 5 – 10	↑ 0 – 12		↑ 0 – 10	0 – 100
30 – 60	Health & Well-being (symptoms)	↓ 5 – 9	↑				0 – 100
55 – 75	Health & Well-being (overall)	↑ 6 – 10	↓ 11 – 12	0		↓ 6	0 – 100

This is a summary of a systematic review of the literature concerning Better Buildings versus other common corporate programs, in terms of their effects on various KPIs. Note that the Better Buildings actions also result in improved environmental performance in addition; the office layout changes were comparisons between cellular and open-plan (but all assigned) layouts. They probably also reduced environmental footprints, but clearly didn't pay off well overall.

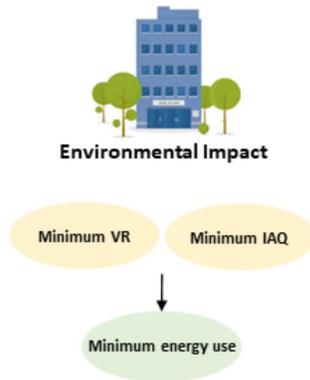
The final Matrix showing the benchmarks for each metric, and the effects of various corporate programs. The benchmark has a purple background if it was derived from national/international statistical surveys, and no background if it was derived from targeted research studies or theory. The arrow in each cell indicates the direction of the effect. The number in cell indicates the size of the effect (in the same units as the benchmark). An arrow without a number indicates that the direction of the effect is established, but a size was not derivable (in our preferred terms) from the published studies. The effects attributed to Better Buildings strategies are highlighted as they are the primary interest of the project.

The number in the cell represents the preponderance of available information, and is based on our judgement (i.e., it is not the result of a quantitative meta-analysis). We present a range if several studies contributed a variety of results. That range might start at zero if several studies found no effect and several found consistent effects. Empty cells denote combinations of corporate strategies and KPIs for which we found no relevant studies on which to base a conclusion.

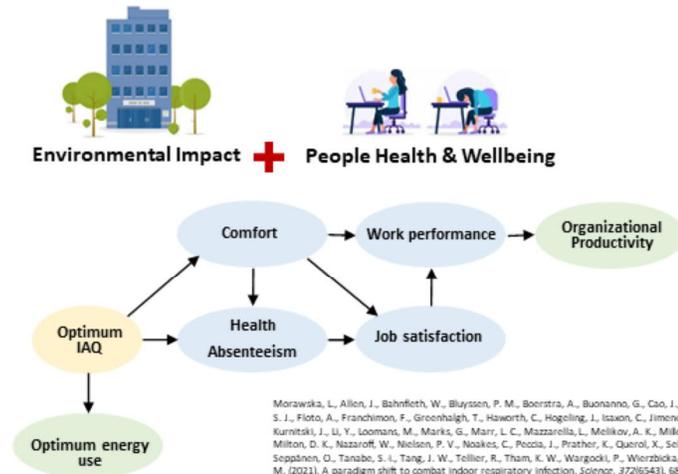
Study results and benchmarks have been rescaled into common units using straightforward assumptions and linear translation, and not any formal statistical method.

Responding to the pandemic: Renewed attention to ventilation

Limited approach:



Comprehensive approach:



We are not alone in suggesting that ventilation is important! Many very smart building scientists and public health professionals are arguing the same thing. We, however, note that many outcomes would improve if ventilation in buildings received more attention. We even have some evidence to contribute from our own work.

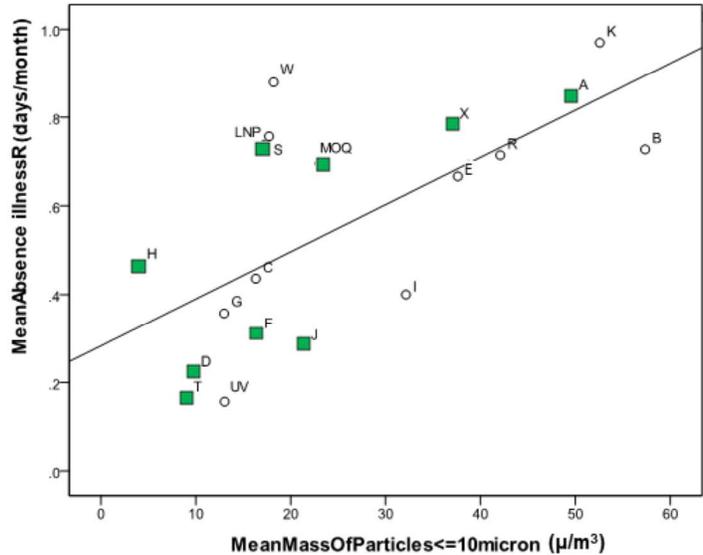
Here too, some of the information is not new – but maybe this is the time to shout louder about it to make it more widely known and applied.

Green buildings POE: IAQ and illness absence

NRC studied matched pairs of green and conventional buildings using this methodology. Here is one result.

For some physical parameters, being in a green building wasn't a guarantee of being in the best conditions, but IAQ was.

Newsham, G. R., Birt, B. J., Arseneault, C. D., Thompson, A. J. L., Veitch, J. A., Mancini, S., . . . Burns, G. J. (2013). Do 'green' buildings have better indoor environments? New evidence. *Building Research & Information*, 41(4), 415-434. <https://doi.org/10.1080/09613218.2013.789951>



This is one outcome from a large cross-sectional field study of 26 buildings across North America for which we had building physical data and employee survey data. This analysis is at the building level. The green squares are data points from Green-certified buildings, and the open circles are from (unrenovated) matched conventional buildings.

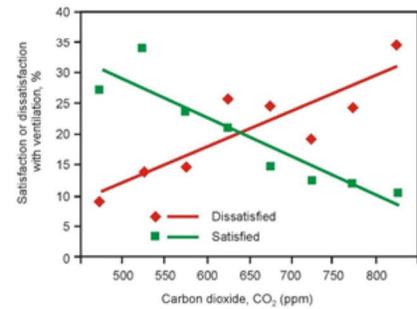
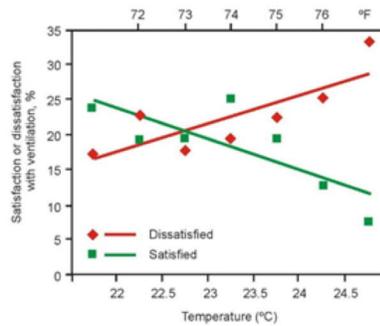
One interesting relationship is here, showing that buildings with higher quantities of particulates larger than 10 microns have higher rates of absence due to illness. Note that some green buildings were bad on this physical outcome (e.g., building A) and some conventional buildings were very good (UV).

Getting ventilation right will have real benefits, and these go beyond the needs of the immediate pandemic. There is also (for instance) literature concerning effects of reduced CO2 on cognitive performance.

Indoor air quality

Our COPE data showed interesting sensitivity of satisfaction to IAQ conditions, too.

Both then and now, the carbon dioxide target for buildings was 1000 ppm, but we found that ~650 ppm was where satisfaction outweighed dissatisfaction.



Charles, K. E., Veitch, J. A., Newsham, G. R., Marquardt, C. J. G., & Geerts, J. (2006). Satisfaction with ventilation in open-plan offices: COPE field findings. In E. de Oliveira Fernandes, M. Gameiro da Silva & J. Rosado Pinto (Eds.), Proceedings of Healthy Buildings 2006: Creating a healthy indoor environment for people (Vol. 2, pp. 93-98). Lisboa, Portugal: International Society of Indoor Air Quality and Climate.

COPE – Cost-effective Open-Plan Environments, an project from 1999-2003. These data are from ~790 workstations in 9 buildings in Canada and the US. Satisfaction data is from surveys completed simultaneously with the field measurements.

Invisible, visible energy benefits

Building controls can deliver energy savings without affecting environmental quality: Smart Building Energy Management (SBEM)

Financial performance

- Installed: ~\$50K per building
- Monitoring: \$10K~\$30K/y
- Business disruption: none
- \$880k; 4 buildings in FY16/17
- ~ 15% energy savings
- < 12 month payback
- Deployed in 13 buildings ('16)

Collateral benefits

- Greater employee engagement via lobby displays
- Better oversight of building management
- Prioritized O&M actions
- Costing of deferred actions, OpEx/CapEx



This slide describes our colleagues' work on smart building energy management (now led by Ian Wilton). The details are not critical here, only to point out that with proper sub-metering and monitoring, buildings can be operated more efficiently in ways that don't affect occupant comfort. A multidisciplinary, focused approach can help to deliver on the ESG goals without trading off one from another. (The lighting example is another.)

The system is now operated in >100 federal government buildings.

Satisfaction with workplace amenities

	OES	ORG_COM	TURNOVER
Age	0.06*	0.02	0.01
Sex	-0.03	-0.07	0.10*
Window Location	-0.01	0.07	-0.01
Workstation Enclosure	0.00	0.01	0.01
Unassigned WS	-0.05	0.06	-0.02
SAT_L	0.16***	-0.12*	0.06
SAT_AP	0.55***	0.16**	-0.21***
SAT_VT	0.08*	0.00	0.01
TRANS_A	-0.03	0.02	-0.02
TRANS_PR	0.00	0.03	-0.01
TRANS_PU	-0.05	0.03	0.03
ONSITE	0.08*	-0.07	0.04
OUTDOOR	-0.13***	-0.03	-0.05
SUSTAIN	0.06	0.02	0.00
IN_OFFICE	0.06	0.04	0.06
FOOD	-0.02	-0.07	0.06
HEALTH	0.10*	0.34***	-0.19*
ACCESS	-0.01	0.02	-0.08
R ² Change- Step 1	0.00	0.01	0.01*
R ² Change- Step 2	0.06***	0.01	0.00
R ² Change- Step 3	0.56***	0.07***	0.05***
R ² Change- Step 4	0.02***	0.07***	0.03*
Total R ²	0.64***	0.15***	0.10***
Adjusted R ²	0.63***	0.12***	0.07***

Concerns expressed about employees' willingness to return to workplaces

Some landlords focusing on support amenities...good decision!

Regression of cross-sectional data on satisfaction with immediate workstation and supporting amenities

Satisfaction with amenities that support health and well-being positively predict overall environmental satisfaction and more strongly predict organizational commitment, and negatively predicts intent to turnover

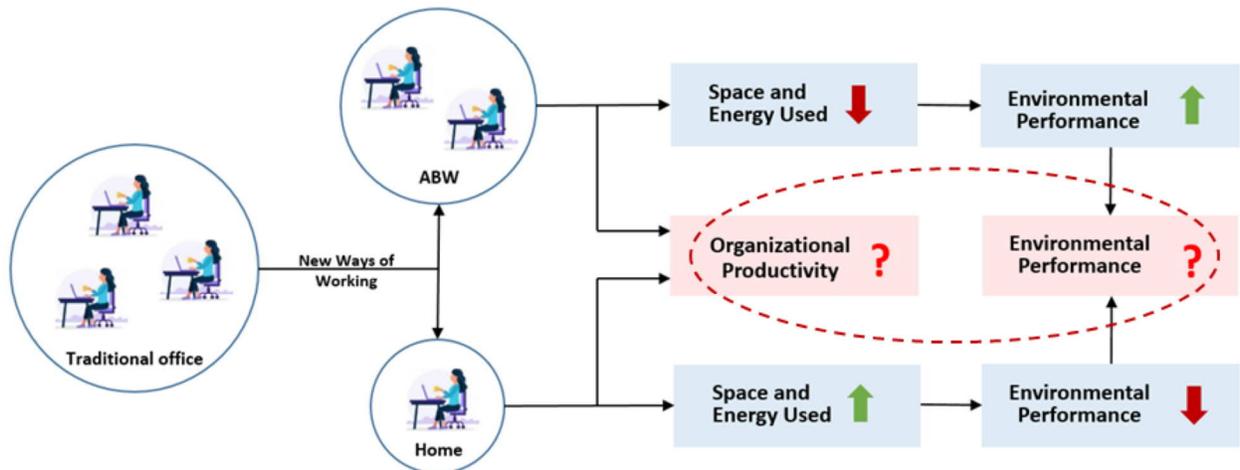
Liu, J., Newsham, G. R., Veitch, J. A., & Gorgolewski, M. [in preparation]. Occupants' satisfaction with building amenities affects organizational productivity.

14

Amenities Related to Health & Well-being (Cronbach's Alpha = 0.75)

- Availability of programs and design features that support a more healthful working environment
- Access to water fountain/bottle refill stations
- Quality of water from water fountain/bottle refill stations
- Natural materials and elements (real or simulated) in the workplace
- Cleanliness and maintenance of public spaces
- On-site amenities and their features: view of nature in amenity spaces
- On-site amenities and their features: fitness
- On-site amenities and their features: healthy food options
- Note also the importance of satisfaction with privacy and acoustics: when it's bad, people are less committed to the organization and have a higher intent to leave.

Hybrid work – fad or future?



15

We hear a lot about the “new way of working” – “people want to work from home”, and this can lead to reduced space costs. If unassigned (ABW) is used, then you can increase space utilization by providing fewer seats than people.

Can show reductions in space needs and reduced organizational GHG emissions, and by increasing the number of people assigned to the space, utilization goes up and costs/sq ft/person go down: looks good for the organization.

but...

This pushes costs and environmental consequences down to individual employees. Not all of them can provide suitable spaces in their homes to support their work. This is especially true of those at the bottom of the totem pole, new to working life, in shared or multi-generational accommodation. For them this might not be a perk or a benefit, but a career-limiting problem. By being at home they miss the team-building and career-building interactions of seeing experienced people regularly in action, and they can slip through the cracks.

What are the societal-level measured results?

How about overall organizational performance?

What if people want to work from home because they don't want to return to the crowded, noisy places where they worked before?

On the organizational side: Note that if \$3/ft² is operating costs; \$30/ft² is capital costs; and \$300/ft² is employee costs, then increasing density could change that to \$3/ft² is operating costs; \$20/ft² is capital costs; and \$400/ft² if you decreased your space by 30% and assigned those people to a building with ABW at a 1 seat: 1.3 people ratio. (I assume that space will still cost about the same for energy and operating.) If there

are problems with the approach that lead people to be less able to produce work of value to the organization, it will not take long before you've used up that \$10/ft² savings.

Conclusions

We have bodies of evidence about how building conditions affect people, but this evidence is not being put into practice fast enough

The herculean efforts of aerosol and ventilation scientists to raise awareness of the airborne spread of COVID-19 is an example of the problem AND an inspiration to the rest of us

Only by taking a comprehensive, multidisciplinary approach can we reach good solutions that benefit planet, people, and profit – also known as environmental, social, and corporate governance (ESG) goals

In closing: A plea for better research designs

Field research is difficult, yes... but let's go back to basics:

Internal validity –

- Exclude extraneous variables
- Intervention studies must have a no-change comparison!

External validity – take care not to over-generalize

Follow the expert guidance!

Cook, T. D., & Campbell, D. T. (Eds.). (1979). *Quasi-experimentation: Design and analysis for field settings*. Boston, MA: Houghton Mifflin.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston, MA: Houghton Mifflin.



We have been conducting several review exercises lately on different aspects of these issues. It's frustrating when we can't reach strong inferences about causation...or even "strong-enough" inferences

A pre-post study with an intervention needs a comparison condition without that intervention! Especially if there is a move involved and a long time between measurement times.

THANK YOU

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