Comparing better building design and operation to other corporate strategies for improving organizational productivity: a review and synthesis

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Comparing Better Building Design and Operation to Other Corporate Strategies for Improving Organizational Productivity: A Review and Synthesis

"Better buildings" are intended to improve employee well-being and other important organizational productivity metrics, but such effects have been notoriously difficult to quantify convincingly. This paper uses new, multi-metric approaches to develop a framework for valuing these effects. The organizational productivity metrics considered are: absenteeism, employee turnover intent, self-assessed performance, job satisfaction, health and well-being, and complaints to the facilities manager. The effects of several ways of improving building design and operation (improved ventilation, enhanced lighting conditions, green building certification measures) are compared to the effects of other corporate strategies also employed with the intent of influencing employees to improve organizational productivity: office type (private vs open-plan), workplace health programs, bonuses, and flexible work options. Results were derived from a broad search and synthesis of published information from several disciplines: business, medicine, psychology, engineering, and facilities management. The scope was limited to studies conducted in real organizations in large office buildings, with a geographic focus on studies from North America, Europe, and Australia/New Zealand. In summary, better buildings strategies provided benefits on multiple organizational productivity metrics at levels similar to other corporate strategies. This supports greater consideration being given to better buildings strategies to improve organizational productivity beyond energy savings. In this paper, and for want of more primary research, the "better buildings" category blends the effects of different improvements; this synthesis is proposed as a starting point to encourage more buildings research in this context, allowing future differentiation of the effects of specific interventions.

Keywords: benchmarks, building operation, office design, organizational productivity

Introduction

Linking Building Systems to Organizational Productivity

Corporate decision-makers desire to maximize organizational productivity, and seek evidence in the form of established metrics and quantifiable economic effects as the basis for their decisions. There is a long history of research establishing linkages between the physical office environment and the comfort of occupants (Brill, Margulis, Konar, & BOSTI Associates, 1984; Sundstrom, 1986). However, linkages between work environments and metrics with arguably a more direct effect on organizational productivity, such as employee health and well-being, and real-world task performance, are less established and recognized.

The potential economic value of this line of enquiry has long-been understood. The cost of staff typically dwarfs the cost of the buildings they occupy. A common rule of thumb is that the annual operational costs of an office space are, on average \$300/ft^2 for staff payroll, \$30/ft^2 for space rent, and \$3/ft^2 for utilities (Best, 2014). Nevertheless, real-estate decisions are more commonly steered by the latter two costs (Oseland and Burton, 2012).

At one time decision-makers sought very simple cause-and-effect relationships; i.e. "If I replace building feature X then the amount of work produced by an individual will increase by Y%". There is increasing acceptance that such a model is not applicable to most white-collar workplaces, where the economic output of an organization is rarely measurable in such simple terms. Instead, productivity is better represented by multiple metrics that all influence the overall balance of costs and revenues in an organization. Modern organizations are now accustomed to multi-metric (or "balanced scorecard") approaches in other domains (e.g. Kaplan & Norton, 1992).

Two recent publications map out an approach to valuing better buildings using multiple metrics. Thompson, Veitch, & Newsham (2014) proposed a scorecard structure, with a focus on the effect of building automation systems (BAS). The World Green Building Council (WGBC, 2014), provided a similar internationally-agreed, multi-metric framework, which included metrics related to: human resources (HR) outcomes, workplace perception, complaints to the facility manager (FM), and physical measures of the indoor environment.

Establishing Values

The balanced scorecard approach recognizes that, (1) not all metrics can be converted in a straightforward, meaningful or universal way into monetary units, and (2) the same metric will have a different monetary value to different organizations. Organizations may choose the metrics that represent their goals and may choose to undergo a monetization exercise using assumptions and multipliers that are unique to them.

Another way to judge the utility of building investments is to compare their effects to other forms of investment that organizations might make, using consistent, metric-specific, units. This is the approach taken here: a comparison between building design and operation interventions against the success of other corporate programs designed to deliver productivity effects. Organizations may weigh the costs and benefits of building technologies against these other programs.

As with building energy efficiency upgrades, the process should begin with benchmarking. Benchmarks enable decision-makers to understand whether or not their own building's metrics are lower than desired. This might motivate them to look at options to improve these metrics, including better building options.

Scope

This investigation is a synthesis of already published material. The literature review included peer-reviewed, contemporary studies in real office buildings, the vast majority of which were in North America, Europe, and Australia/New Zealand. Data to facilitate a formal meta-analysis were not available; rather this work is a semi-quantitative synthesis of studies across multiple disciplines with substantial variation in methods. Nevertheless, where applicable, this work followed the PRISMA framework for literature reviewing (http://www.prisma-statement.org/) in its development and reporting.

Goal

This work represents the first attempt (to the authors' knowledge) to put the effects of buildings on multiple, individual-level organizational productivity metrics side-by-side with the effects of other corporate strategies in order to learn how the effects compare in size and direction. This comparison may bring the value of investing in buildings to greater prominence in the eyes of HR and corporate decision-makers.

Numerous studies and reviews have addressed the broad topic of the effects of various indoor environment conditions on occupant comfort, and on corporate strategies more generally on aspects of productivity. However, these studies have been typically limited to single disciplines. Further, prior studies that focussed on the effects of buildings (e.g. Newsham et al, 2009; Al Horr et al, 2016; Appel-Meulenbroek & Feijts, 2007), for example, have limitations in providing convincing information to corporate decision-makers. Shortfalls include no systematic definition of productivity as an outcome; frequent reliance on a single, very narrow dependent variable as a measure of productivity; failure to quantify effects in a format that is interpretable by corporate

decision-makers; and, excessive reliance on laboratory studies that have limited real-world context. This work provides a unique contribution in several ways:

- Effects are presented for a specific and consistent set of broadly accepted productivity-related metrics;
- Effects are compared from multiple disciplines and corporate strategies on the same metrics;
- Focus is on results derived from real workplaces.

Review and Analysis Framework

Definition of Key Performance Indicators

This investigation focused on making effects clear to corporate decision-makers and comparable, despite the wide variety in information sources and disciplines included in the review. Outcomes derived using different scales were rescaled to a common scale to improve interpretation using a procedure described below.

Absenteeism (unit: Days/person/year)

Organizations code absences in various ways, making comparisons difficult. The focus of this review was on short-term sick leave that an employee takes based on their own health assessment. This type of absence seems more likely to be attributable to the office environment than long-term absences or those taken to support family members.

Employee Turnover (unit: 0-100 scale (likelihood to look for another job))

The focus of the chosen metric was on whether someone leaves their job voluntarily, again because the office environment might contribute to such a decision (American Society of Interior Designers (ASID), 1999). Turnover rate is typically listed in national

statistical databases, based on industry reporting. Turnover intent is more frequently used as a survey question in research studies and social surveys, and is the focus here. A typical question might read, "How likely is it that you will make a genuine effort to find a new job with another employer within the next year?" Note that if the response is mapped to a 0-100 scale, an average response of 25 would mean that employees say they are "somewhat unlikely" to be looking for another job, not that 25% of employees are actively looking for a new job.

Self-assessed Performance (unit: 0-100 scale)

Objective measures of task performance in real workplaces are not often available to researchers for publication, if indeed they exist at all for many occupations. However, there exist several studies in which employees had been asked to self-assess their own productivity. A typical question phrasing by researchers might be, "Please estimate how you think your personal productivity at work is increased or decreased by the physical environmental conditions", with a seven-point response scale from -30% to +30% (Wilson & Hedge, 1987). There is some debate as to the interpretation of this metric. It is unlikely to be a reliable measure of an employee's actual material output, and is more likely a measure of how the indoor environment supports the employee's ability to do their job.

Job Satisfaction (unit: 0-100 scale)

Job satisfaction is the antecedent to many other workplace behaviours that affect an organization's productivity (Roznowski and Hulin, 1992, p. 158). Many different question wordings have been used, and judgement was applied to interpret the equivalence of different question formats for rescaling purposes.

Health and Well-being (symptoms) (unit: 0-100 scale)

In the buildings research domain, Sick Building Syndrome (SBS) events led to the use of surveys to assess associated symptoms. These symptoms included dry eyes, runny nose, back pain etc., and surveys sought to isolate symptoms that occurred in the workplace, but receded when the employee went home.

Health and Well-being (overall) (unit: 0-100 scale)

Both national and international social surveys and individual research studies have been used to determine an individual's general state of health or well-being.

Complaints to Facility Manager (unit: complaints/person/year)

These data are routinely recorded by the building managers in most large office buildings. Complaints are typically related to unsatisfactory temperature, air quality issues, cleanliness, lamps burned out etc.

Definition of Corporate Strategies to Improve Organizational Productivity

The focus of this work was strategies that would be familiar to a building manager, or which might be implemented with the participation of the building manager. The strategies are categorical and could encompass numerous specific actions.

Better Buildings

Studies included upgrades to specific building systems (e.g. ventilation enhancement, advanced lighting controls), or whole-building approaches typically including a collection of enhanced elements (e.g. green building certification). For this review, different specific building interventions were grouped into an overall better buildings strategy. The intent of this work is to enable decision makers less familiar with

buildings to appreciate that building improvements, in general, have effects comparable to other corporate strategies. Further, there are not enough studies of any one intervention type to be able to see reliable effects across multiple metrics (the specific building interventions are detailed in Appendix C).

Office Type

Private offices were compared to open-plan accommodation. This is a scenario that has been studied relatively frequently, as it is a design option explored by a large number of organizations.

Workplace Health Programs (WHP)

WHPs often form part of the benefits package in large organizations, typically offered as bundles of measures; e.g., health counselling, gym access, nutrition programs, stress management, medical tests (e.g., blood pressure). These are distinct from health insurance benefits, which differ widely from one country to another and were therefore outside the scope of this review.

Bonuses

It is a common belief that financial incentives will elicit employee behaviours that will benefit organizational productivity. This review focused on bonuses provided for general job performance, typically evaluated by a manager, rather than bonuses for a specific behaviour.

Flexible Work Options

Studies have typically looked at a package of options, and might include flexibility in scheduling working hours in the organization's own building, the availability of

multiple workplace locations within the building, or the ability to telework.

Literature Search

The bibliographic databases and sources searched were: Scopus, PsycInfo, Google Scholar, APA Center for Organizational Excellence, Conference Board of Canada. For the benchmarks, the sources were: General Social Survey (University of Chicago), US Dept. of Labour, Labour Statistics, Statistics Canada, Nobscott Statistics, National Institute for Occupational Safety and Health (NIOSH), Organization for Economic Co-operation and Development (OECD), Gallup, General Social Survey. The list of search terms is shown in Appendix A. Table 1 shows the number of publications identified and those used to derive the results. Over 550 abstracts were reviewed, and if the abstract looked promising the full paper was obtained and read. If the contents of the paper passed the screening criteria, and provided results in a format compatible with the derivation of the main effects of treatments/strategies, then it was included in the final results table.

For inclusion in this investigation, studies needed to include a comparison between the outcomes with and without the target strategy, or to be a meta-analysis or review of the topic. Papers were examined to ensure that the work met criteria for research quality. Results were required to be reported in sufficient statistical detail in order to enable comparisons and, if necessary, to rescale results from heterogeneous studies into equivalent units. Appendix B explains the rescaling method, for those studies that required it.

[Table 1 Here]

Results

Table 2 presents a tabulated summary of the results[i]. This is supplemented below by a narrative section on each KPI, describing the benchmark derivation and citing studies used to derive the effects of strategies, and other supporting studies. The numbers in the cells in the body of Table 2 represent the preponderance of available information in studies that met the inclusion criteria, and is based on judgement (i.e., it is not the result of a quantitative meta-analysis). If several studies contributed a variety of results, the cell shows the range. That range might start at zero if several studies found no effect and several others found consistent, non-zero effects. An arrow indicates the direction of the effect. Empty cells denote combinations of corporate strategies and KPIs for which no relevant studies that met our inclusion criteria were found. Appendix C provides details of the studies that contributed to the conclusions for each cell of Table 2.

Table 2 shows only simple main (direct) effects. These are easy to interpret, but there are likely to be indirect effects as well. For example, if a strategy improves job satisfaction, there would likely be a consequent reduction in employee turnover, even if there are no studies for that strategy directly evaluating retention effects. These indirect effects are not explicitly addressed in Table 2 nor in this paper.

[Table 2 Here]

Absenteeism

Absenteeism: Benchmarks

Absenteeism data are available from national statistical databases, but there are differences in how each country's data are compiled[ii]. Self-report data are shown here

because they are more directly comparable to the scientific studies of the effects of strategies.

Figure 1 shows OECD (2017) data, which is the best source of country-to-country comparison. Some of the variation between countries may be methodological, although other differences caused by differences in culture, health care provision, and employment contract norms may also be expected.

Figure 1. Absenteeism data from multiple OECD countries; if a country has data for more than one year the value shown is the mean over those years.

Within countries, there is often considerable variation in absenteeism by industry type. Table 3 shows data by industry type for Canada (Statistics Canada, 2016). Therefore, for benchmarking a national average might be of limited value, and a corporate decision-maker might be well-advised to consider industry-specific data.

[Table 3 Here]

Newsham et al. (2013) conducted a post-occupancy evaluation of 12 "green" and 12 matched conventional buildings across Canada and the Northern USA. Mean self-reported sick leave was equivalent to 7.1 days/pers/yr (N=782), consistent with the national data sets.

Absenteeism: Effects of Corporate Strategies

Effects of Better Buildings: Not surprisingly, these depend on the specific better building feature: Milton, Glencross, and Walters (2000) found that a higher outdoor air supply rate (~24 l/s/pers) was associated with 1.2-1.9 days/pers/yr lower sick leave

depending on age and gender, compared to a lower outdoor air rate (~12 l/s/p). Niemela, Seppanen, Korhonen, and Reijula (2006) reported that an air quality intervention (cleaning the ventilation system, replacement of duct lining, and air flow balancing) was associated with a reduction in short-term absenteeism equivalent to 0.65 days/pers/yr. Veitch, Newsham, Mancini and Arsenault (2010) found that new direct-indirect electric lighting with personal dimming control allied with new office furniture (lower, lighter-coloured panels defining cubicles) compared to the pre-existing electric lighting of direct parabolic luminaires with older office furniture (higher, darker-coloured panels) was associated with a reduction in absenteeism of 0.4 days/pers/yr. Preller, Zweers, Brunekreef, and Boleij (1990) also found that elements of personal control, in their case ability to adjust temperature and open windows, were associated with lower sick leave. Singh, Syal, Korkmaz, and Grady (2011) observed statistically-significant, though small improvements in staff absenteeism following a move from conventional to green (LEED certified) buildings, but effects were limited to employees with specific medical conditions (e.g. asthma, respiratory allergies).

Effect of Office Type: Pejtersen, Feveile, Christensen, and Burr (2011) demonstrated that private offices were associated with 3.2 days/pers/yr lower sick leave compared to open-plan offices with more than six occupants (any office with more than one occupant was associated with higher sick leave)[iii]. Bodin Danielsson, Chungkham, Wulff, and Westerlund (2014) also reported an overall trend for open-plan spaces to have a higher (risk of) sick leave than private offices.

Effect of Workplace Health Programs: Baicker, Cutler, and Song's meta-analysis (2010) suggested an (unweighted) mean reduction of 1.8 days/pers/yr due to WHPs[iv]. Kuoppala, Lamminpaa, and Husman's (2008) review of multiple studies concluded that

"There is moderate evidence that work health promotion decreases sickness absences". Marzec et al. (2011), however, found no statistically-significant effect.

Effect of Bonuses: Pfeifer (2014) found that higher achievable bonus payments correlated with fewer sick days. The most conservative estimate of the effect was a reduction of absenteeism of 29% (equivalent to 1 day/pers/yr) for each log-point increase in the maximum achievable bonus. A one log-point increase in this sample, in the middle of the range, was equivalent to around €8500.

Effect of Flexible Work Options: In Whyman and Petrescu (2015), home or mobile working was associated with higher absenteeism (by 2.5 days/pers/yr); and, family-friendly practices were linked to lower absenteeism levels (by 2.8 days/pers/yr). Dionne and Dostie (2007) examined a variety of work arrangements, including working from home, and flexible hours. Many statistically-significant effects were found in both directions, but these effects were very small, and of little practical significance.

Employee Turnover

Employee Turnover: Benchmarks

National-level data on turnover intent are typically captured in social surveys directed at households. Medina (2012) looked at the 2010 data for the University of Chicago General Social Survey[v] (N=4618) and reported that the average likelihood of looking for a new job was 23 on a 0-100 scale. This is comparable to other North American samples: The University of Michigan Work, Family and Health Study (2015) aggregated data over 2009-2012 from two US companies (IT and extended care, N=9148) and reported an average likelihood of looking for a new job of 30 on a 0-100 scale. Similarly, Newsham, et al. (2013) recorded a turnover intent score of 28 (N=835,

office employees in Canada and the northern US, data from 2010-2011). Turnover intent appears to be lower in Japan, with a score of 18 for 2010 (Tanioka, Maeda, & Iwai, 2010).

Employee Turnover: Effects of Corporate Strategies

Effect of Better Buildings: Veitch et al. (2010) measured turnover intention using the same scale as Newsham (2013). Direct-indirect electric lighting with personal dimming control allied with new office furniture was associated with a 1.3 point reduction in turnover intent compared to the pre-existing electric lighting and furniture.

Effect of Office Type: A subset of data from Leder, Newsham, Veitch, Mancini, & Charles (2016), limited to conventional buildings in the sample, indicated an 18-point lower intent to turnover score in private offices compared to open-plan offices; there were no statistically-significant main effects by job type or tenure. Oldham and Fried (1987) concluded that, "… Employees were most likely to withdraw from offices and to experience dissatisfaction with their work when the following conditions were present simultaneously: the office was rated as dark, few enclosures surrounded employees' work areas, employees were seated close to one another, and many employees occupied the office."

Effect of Workplace Health Programs: Caillier (2016) found no direct effect of health and wellness programs on intent to turnover.

Effect of Bonuses: Studies in this category reported actual turnover, not intent to turnover, but there was insufficient information to form a numerical conclusion. Park and Sturman (2016) found that all forms of pay-for-performance were associated with lower turnover when considered independently. When applied collectively, merit pay

had the strongest negative association with employee turnover, followed by long-term incentives, whereas bonus pay actually increased employee turnover. Overall, effects were greatest for higher performing staff. Salamin and Hom (2005) found that both merit pay increases and bonuses were associated with sizable reductions in quit rates, and, overall, effects were greatest for higher performing staff. In Nyberg (2010), both higher total compensation and employee perception that higher performance was rewarded, were associated with lower turnover rates. Again, overall, effects were greatest for higher performing staff.

Effect of Flexible Work Options: No relevant studies were identified.

Self-assessed Performance

Self-assessed Performance: Benchmarks

There appear to be no relevant national level databases. Given the typical format of such questions (-30% to +30% scale), one would expect that an environment that is neutral would yield a value of zero. For example, Veitch, Charles, Farley, & Newsham, (2007) collected data from nine office buildings across Canada and the USA; the mean response was -1.5% (N=747). Newsham, et al. (2013) recorded a mean response of 0.1% (N= 2523).

Self-assessed Performance: Effects of Corporate Strategies

Effect of Better Buildings: Singh et al. (2011) found a 2% improvement in perceived productivity associated with the move to green buildings. Agha Hossein, El-Jouzi, Elmualim, Ellis, and Williams (2013) found the equivalent of a 5% improvement in self-assessed performance associated with staff moving from an older HQ building to a structurally similar, but newly refurbished, building located next-door; the

refurbishment achieved a high sustainable building certification. Baird, Leaman, and Thompson's (2012) analysis of data from a worldwide set of buildings reported a statistically-significant difference in the effect of environmental conditions on perceived productivity of 7.8% favouring sustainable buildings. Thomas (2010) reported an improvement of 9.6% in self-reported productivity associated with a staff move from a conventional building to a new building with a superior sustainability certification. In Oseland and Burton (2012), office workers in 1950s legacy buildings indicated a mean perceived productivity rating 2.2% lower than in more recently-built buildings, and 4.8% lower than in the newest building.

Effect of Office Type: Data from Newsham, et al. (2013) indicate a statistically significant main effect of office type, suggesting a 7.7% improvement associated with private offices[vi]. Bergstrom, Miller, and Horneij (2015) studied office workers moving from private to open-plan offices and found the equivalent of an 8.1% decline in perceived productivity associated with the move. Brennan et al. (2002) studied office workers moving from (mostly, 76%) private offices in a downtown high-rise to (mostly, 81%) shared/open-plan offices in a business park. A decline in perceived productivity equivalent to 13.0% was associated with the move. Lee's (2010) study of LEED-certified buildings indicated that private offices had statistically-significantly higher perceived productivity scores than all types of shared or open offices. For example, the mean response from private offices was 14.6% higher than for high-panel cubicle offices.

Effect of Workplace Health Programs: Coffeng et al. (2014) found a statistically-significant effect of WHP equivalent to ~5-10%. Rongen, Robroek, van Lenthe, and Burdorf's meta-analysis (2013) included five studies conducted in an office-like setting.

Two of these included a measure of productivity, one of which showed a significant positive effect of a WHP, and the other showed no effect. Other studies have demonstrated no effect of WHPs on self-reported performance (Vuokko et al., 2015; Blake, Zhou, and Batt, 2013; Pereira, Coombes, Comans, and Johnston, 2015).

Effect of Bonuses: Studies in this section typically used an objective performance metric, rather than a self-assessed measure. In Stajkovic and Luthans (2001), simple bonuses for increased performance were associated with a statistically-significant improvement in performance over baseline of 11%; bonuses allied with a formal process to identify organizational deficiencies increased performance by 32%. In O'Neill (2014), although there was an increase in mean sales per week after a bonus was applied, this difference was not statistically significant. However, when the bonus was subsequently removed, there was a statistically-significant decrease in sales of 22.4%. In Raj, Nelson, and Rao (2006), employees (N=18) who were offered monetary rewards and extra paid leave exhibited significantly higher performance assessed by management-appointed observers. Nevertheless, other non-monetary interventions (feedback, flexible dress code, flexible working hours) had similar or larger benefits.

In Lowery, Petty, and Thompson (1995), of all employees, 70% agreed that the bonus plan had a positive effect on their work habits and performance, but only 47% agreed that it had improved their personal productivity; nevertheless, 70% agreed that it had improved the company's performance. Garbers and Konradt's meta-analysis (2014) showed that the overall effect of incentives for individuals (116 studies) was statistically significant, and positive. Effects were larger for qualitative, rather than quantitative, performance measures, and for more complex tasks.

Effect of Flexible Work Options: No relevant studies were identified.

Job Satisfaction

Job Satisfaction: Benchmarks

Benchmarks for job satisfaction exist in national and international social surveys. Typically these data came from the working population as a whole, and were not limited to office workers. The University of Chicago General Social Survey (2016) shows an average of 65-66 on a 0-100 scale between 2002-2014, based on ~2000-4500 respondents in the USA general population. The University of Michigan Work, Family, and Health Study (2015) reported average job satisfaction was 78, and Gallup data (2017) show an average job satisfaction of 67-76. Workplace survey results are consistent: Newsham, et al. (2013), average = 77. Veitch, et al.'s (2007) average = 68.

The range of job satisfaction averages is similar around the world. The Japanese average was 66 (Tanioka et al., 2010), and Figure 2 presents the mean responses in 2013 from a sub-set of European countries (Eurostat, 2015).

Figure 2. Job satisfaction data for a sample of European countries.

Job Satisfaction: Effects of Corporate Strategies

Effect of Better Buildings: In Veitch et al. (2010), direct-indirect lighting with personal control (+new cubicles) was associated with an improvement in job satisfaction of 6 points when normalized to a 100-point scale, compared to direct parabolic lighting (+old cubicles). Hongisto, Haapakangas, Varjo, Helenius, and Koskela (2016) studied a collection of work environment improvements, including better environmental conditions (e.g. sound absorption, odour mitigation) and control (e.g. personal light

switches), increased privacy, and more ergonomic furniture (including sit-stand desks). The refurbishment was associated with a statistically-significant increase in job satisfaction of the equivalent of 4 points. In Agha Hossein et al. (2013), the newly refurbished office was associated with a statistically-significant increase in job satisfaction of the equivalent of 9 points.

On balance, studies suggest that "better buildings" are associated with higher overall job satisfaction. However, Newsham, et al. (2013) found no statistically-significant difference in job satisfaction between green and conventional buildings. Similarly, McCunn and Gifford (2012) also found no correlation between the number of green or sustainability features present in a building and the overall engagement of employees in their work (a composite variable including self-reported productivity, affective organizational commitment, and job satisfaction).

Effect of Office Type: In Bergstrom et al. (2015), the prior, private offices were associated with a statistically-significant higher mean response of the equivalent of 10 points, compared to the new open offices. Pejtersen et al. (2011), found a systematic decline from single-person offices to offices shared with increasing numbers of people. The comparison of private offices to the largest shared spaces was associated with a higher mean response of the equivalent of 4.7 points. Bodin Danielsson and Bodin (2009), asked whether "the workspace design did not contribute to job satisfaction". There was a statistically-significant effect of office type, with 31% of occupants of private offices agreeing with this statement, compared to 64% of the occupants of large open-plan offices. De Croon Sluiter, Kuijer, and Frings-Dresen's review of 49 studies (2005) concluded that "… working in open workplaces reduces privacy and job satisfaction." Oldham and Fried (1987) found that 31% of the variance in "work

satisfaction" was attributable to four workplace characteristics: social density, number of enclosures, interpersonal distance, and room darkness; the first three characteristics all relate to office layout, and the maximum enclosure value would correspond to a private office.

Effect of Workplace Health Programs: In Caillier (2016), results indicated a statistically-significant and positive association between health and wellness programs and job satisfaction, equivalent to a 12-point improvement. Conn, Hafdahl, Cooper, Brown, and Lusk's meta-analysis (2009) found a statistically-significant and positive effect, in which physical activity programs improved job satisfaction for studies of one research design type (two-group pre-post) but not for two other research design types (two-group post-test, treatment pre-post). Marzec et al. (2011) found no effect on job (dis)satisfaction. Blake et al. (2013) did show a statistically-significant improvement in job satisfaction associated with the wellness intervention, but the size of the effect was so small as to have no practical significance.

Effect of Bonuses: In Lowery et al. (1995), only 46% of all employees agreed that the bonus plan had a positive effect on their job satisfaction, although the figure was 61% for the sub-group of employees who were managers.

Effect of Flexible Work Options: Fonner and Roloff (2010) compared teleworkers who worked remotely at least three days per week with office-based workers who were in an office environment at least three days per week. The direct effect of telework was a statistically-significant improvement in job satisfaction of the equivalent of 10.3 points. Consideration of indirect effects, through benefits of telework on aspects including work-life balance, information exchanges, and management of interruptions, elevated the improvement. Conversely, in Caillier (2016) there was no significant effect of

flexible work options, neither telework nor flex-time, on job satisfaction. Nijp, Beckers, van de Voorde, Geurts, and Kompier (2016) found no statistically-significant effect of temporal and spatial flexibility in work patterns on job satisfaction.

Health and Well-being (symptoms)

Health and Well-being (symptoms): Benchmarks

National statistical databases or social surveys appear not to address SBS-like symptoms in the general population. The benchmarks shown in Table 2 are based on research study populations (Newsham et al., 2013; Hongisto et al., 2016) in conventional buildings or prior to any intervention hypothesized to improve symptoms. Both of these studies measured frequency of occurrence of a collection of multiple symptoms. Although the specific symptoms, and the response scale differed between in the studies, in both cases a score of zero meant no symptoms ever occurred, and a score of 100 meant all symptoms occurred all the time; see Appendix B.3 for details. Physical symptoms average 32 (Newsham et al., 2013) to 56 (Hongisto et al., 2016) on a 0-100 scale; visual symptoms tend to have lower frequency of occurrence for individuals: 29 (Newsham et al., 2013) to 45 (Hongisto et al., 2016).

Health and Well-being (symptoms): Effects of Corporate Strategies

<u>Effect of Better Buildings</u>: Hongisto et al. (2016) tested a set of work environment improvements, which was associated with a statistically-significant reduction in throat symptoms. Mean frequencies were reduced for all other symptoms, including a notable trend for reduced headache, suggesting a reliable reduction in symptoms overall; the size of the effects was equivalent to 4-9 points. In Newsham et al. (2013), green buildings were associated with a statistically-significant reduction in both visual and

physical symptom frequency, compared to conventional buildings; the size of the effects was equivalent to 7 (visual) and 5 (physical) points. In MacNaughton et al. (2017), participants in green buildings reported 30% fewer sick building syndrome symptoms, compared to participants in similar conventional buildings. Interestingly, participants in green buildings also reported better sleep quality, a finding that agrees with a similar beneficial association with green buildings reported by Newsham et al. (2013). In Marmot et al. (2006), a combined measure of workstation control (ability to adjust heat, artificial light, to open the window, and fewer than 10 people in the room) was associated with a statistically-significant reduction in symptoms. Seppanen et al. (1999) synthesized results from multiple studies in real buildings examining the effect of ventilation rate on SBS symptoms. In Fisk et al. (2009) additional studies were considered in producing an average overall relationship. Symptom prevalence was measured in many different ways across studies. Nevertheless, on average, and assuming a baseline symptom prevalence of 20%, an increase in ventilation rate from 10 l/s/pers to 25 l/s/pers was associated with a reduction in symptom prevalence of 6.8%.

Effect of Office Type: Pejtersen Allermann, Kristensen, and Poulsen (2006), studied 14 symptom types, finding that all but two had a statistically-significant lower report frequency in private offices compared to large, open offices. Herbig, Schneider, and Nowak (2016) reported that working in an open-plan office was associated with a statistically-significant increase in cumulative complaints compared to private offices.

Effect of Workplace Health Programs: No relevant studies were identified.

Effect of Bonuses: No relevant studies were identified.

Effect of Flexible Work Options: No relevant studies were identified.

Health and Well-being (overall)

Health and Well-being (overall): Benchmarks

The OECD publishes data on perceived health status for their member countries (OECD, 2015). Methodology varies by country, but is generally based on a single item, such as asking respondents to rate their health as "excellent", "good", "fair", or "poor" (Bowling, 2004), . The following multipliers converted this to a 0-100 scale: "Good or very good"=80; "fair"=50; "bad or very bad"=20. The result is shown in Table 4.

[Table 4 Here]

The cited studies below used different scales to evaluate various concepts of overall health or well-being. For comparison, each of these concepts was treated as equivalent, and each scale was converted to a 0-100 point score where a higher score meant better well-being, as with the OECD benchmark. Details for each study are shown in Table C6.

Health and Well-being (overall): Effects of Corporate Strategies

Effect of Better Buildings: Baird et al.'s analysis (2012) suggested an improvement in overall health of the equivalent of approximately 10 points attributable to sustainable buildings. In Agha Hossein et al. (2013), a move to the refurbished building was associated with the equivalent of a 6-point improvement in self-assessed health.

Effect of Office Type: Bergstrom et al. (2015) reported the equivalent of a 12-point drop in self-reported overall health associated with the move from private to open-plan offices. Herbig et al. (2016) found that working in an open-plan office was associated with a statistically-significant decrease in mental well-being, equivalent to 11 points.

Seddigh, Berntson, Bodin Danielson, and Westerlund (2014) found no main effect of office type on general health, but private offices were associated with lower reported levels of cognitive stress. Pejtersen et al. (2006) found no statistically-significant difference between office sizes on general health and mental health.

Effect of Workplace Health Programs: Marzec et al. (2011) reported no statistically-significant change in health risk as a result of wellness interventions and no effect on self-reported stress. There was, however, a statistically-significant reduction on life dissatisfaction, but a statistically-significant increase in blood pressure. Kuoppala et al. (2008) reviewed seven studies conducted in an office setting, and concluded that WHP had no effect on physical well-being. Rongen et al.'s meta-analysis (2013) included two office studies that included a measure of general health. One of these showed a significant positive effect of a WHP, whereas the other showed no effect. Butterworth, Linden, McClay, and Leo (2006) found no significant effect of WHPs on physical health, but there was a significant improvement of 3.5 points on mental health. Vuokko et al. (2015) reported no effective improvement in physical or mental health from a WHP intervention. Blake (2013) reported no effect on general health or mood.

Effect of Bonuses: No relevant studies were identified.

Effect of Flexible Work Options: Nijp et al. (2016) found no statistically-significant effect of temporal and spatial flexibility in work patterns on stress. There were statistically-significant, but small effects on both fatigue and general health. There was actually a decline in self-reported health equivalent to 6 points associated with flexibility in work patterns.

Complaints to the Facilities Manager

No relevant studies pertaining to any organizational strategy were identified. Nonetheless, there is some related work that can inform further investigation. Federspiel (1998) analyzed complaint logs from more than 600 US buildings. There were more than 4,000 complaints related to environmental conditions, and thermal sensation was the biggest single cause. Most complaints were the result of poor control performance and heating, ventilation, and air-conditioning (HVAC) system faults, and thermal sensation complaints took, on average, around two hours of technician time to resolve. Further, Wang, Federspiel, and Arens (2005) established a statistically-significant correlation between dissatisfaction with the thermal environment, assessed via survey, and unsolicited complaints to the facility manager.

Discussion and Recommendations

The goal of this work was to take a broad look at the available information across multiple metrics, methodologies and domains; the value of this study is in the comparisons it facilitates. There were relatively few studies that met the inclusion criteria, and adequate information was not available to facilitate a reliable formal meta-analysis. Given the breadth of disciplines and outcomes, no such review could claim to be truly comprehensive with any reasonable set of resources. Nevertheless, the literature search conducted in this study was very broad, and given its consistent framework, provides a sound basis for further development. Further, our interpretation and rescaling of results from multiple diverse studies onto common scales required a certain degree of subjectivity: Data were not available or suitable for a more formal meta-analysis. Thus, this work is better considered as a semi-quantitative assessment necessitating some informed assumptions. The literature review found no similar comparisons published

elsewhere. Although certainly not definitive, this work is a useful starting point to inform future work on the full valuation of "better buildings" technologies, and to open dialogue with organizational decision-makers concerning the connections between real estate and HR departments.

The review showed consistently that, in general, "better buildings" offer benefits across multiple productivity metrics that are comparable in size to the benefits from other corporate programs. The Stoddart Review (2016) concurred that improving the physical environment in workplaces is an important and under-recognised lever to increasing productivity. Comparison to other corporate programs provides an appealing and meaningful basis for corporate decision-makers to value "better buildings" investments. However, "better buildings" as defined here is a broad category including different intervention types, this was simply because there was an insufficient number of primary sources that met our inclusion criteria on which intervention-specific conclusions could be based. Although one may conclude that improvements in building environments generally may be reasonably expected to have positive effects on corporate KPIs, decision-makers will likely need more specific information. It is hoped that this paper will stimulate future buildings research to be designed to deliver more such information. Thus, it remains for future research to develop clear guidance concerning the effects of specific better buildings strategies on the full slate of KPIs, to enable decision-makers to choose between alternative ways to improve their buildings and to have the best overall effect on their organization's performance.

Further, enhancement of the productivity metrics with investments in buildings will, in many cases, have benefits not only to the organization, but also to the individual employees, and society in general. This is particularly true with respect to effects on

occupant health and well-being.

The effects in Table 2 are likely not additive. Nevertheless, one might expect a second positive strategy to have a positive effect, although perhaps a smaller effect than it would have if it were applied first. The analysis here focussed on direct effects, but some cited studies did look at indirect effects and effects of strategies on multiple productivity metrics.

Although the effect sizes of different strategies may be similar in their outcomes, the mechanisms might be quite different. A private office might reduce absenteeism by limiting the airborne transport of pathogens, whereas a bonus might reduce absenteeism by eliciting greater enthusiasm for time on task, for example.

In addition to the overall effects of "better building" strategies, the data show also show consistently that private offices produce better outcomes than open-plan offices. This is supported by the large dataset collected under the Leesman Index (2016). Despite this, open-plan offices dominate the market. Two explanations are often suggested: savings in real-estate costs; and, the belief (with little support in objective data (Brill et al., 2001; Veitch, 2012)) that open offices enhance collaboration and communication. Nonetheless, the overall organizational productivity consequence of abandoning private offices for all job types might not be what organizations expect.

Although the directions of effects in Table 2 are almost always as hypothesized, and in agreement with common sense, we cannot rule our publication bias among the primary sources available to our review. Studies that found null results, or results that contradicted common hypotheses, might not have been submitted or accepted for publication. Further, the number of studies that passed our inclusion criteria, and on

which the stated effect sizes are based, is surprisingly limited. Thus, new information could change the magnitude, and possibly the direction, of some effects. These results cannot be considered robust until more studies have been completed.

There are several workplace outcomes that have a high emerging profile among white-collar organizations, but which do not have associated study data to allow them to be metrics in this study. One example of this is employee engagement; there are industry surveys on engagement[vii], but there is no firmly established operational definition among researchers (e.g. Byrne, Peters, & Weston, 2016). Other concepts that managers and designers often expect to improve via workplace design, but which await validated outcome measures, include creativity (Stokols, Clitheroe, & Zmuidzinas, 2002), communication, attraction (of new employees), and presenteeism (Hemp, 2004). One avenue for future work would be to establish valid, reliable measures for these concepts and to demonstrate their sensitivity to building characteristics.

Despite the fact that the task performance of individuals is not synonymous with organizational productivity in the modern service-based economy, the performance of individuals does play a role. It would be very valuable for researchers to develop meaningful, generalizable ways to quantify employee performance in the white-collar workplace. One possibility would be to use standardized testing, as in MacNaughton et al. (2017): Office workers completed standard cognitive function tests. Participants in green buildings scored 26.4% higher than participants in similar conventional buildings. Although this standard task represents only one component of the work behaviours necessary for an employee to make a positive contribution to organizational productivity, the direction of the effect is as many would predict.

The growth of IT in the workplace will create new ways to measure the outcomes

examined here and to develop new metrics for organizational productivity. For example, the increasing density of sensors at fixed locations (e.g. integrated into new LED lighting systems) together with objects that form the "Internet of Things" (IoT) and data from wearable sensors carried by occupants, could be used to track assets, space use, communication patterns, occupancy etc.

To facilitate comparisons between studies, researchers should coalesce on standard methods of evaluating organizational productivity metrics. Where applicable, choosing methods that are used by national statistical organizations (or similar), and which form the benchmarks in this study, would be valuable. Such methods are then validated with large datasets, and have a point of reference that is maintained over time.

Another barrier to the effective comparison of studies was diverse standards of reporting, particularly with respect to potential use of the information by corporate decision-makers who are not research experts. Researchers should report basic descriptive statistics such as means and standard deviations, even when the focus is correlations between variables or tests of causal theory. Simple main effects could deflect attention from more complex interactions, moderating and mediating effects etc., but if work is to affect practice positively, results must be presented in a manner that is meaningful and actionable by corporate decision-makers. Recognition of main effects may be an appropriate stimulus to the exploration of more subtle interactions.

There is also a strong need for longitudinal data and analysis. Many of the studies cited here are cross-sectional, and often illustrate correlations. In most cases there are sensible hypotheses and mechanisms from which to imply causation, but these should be proven in future research. Long-term data collection could also verify whether effects persist over time.

A surprising gap in the literature was the lack of studies employing complaints to the facility manager as an outcome. These data are routinely collected and archived in most large organizations. Responding to a complaint has tangible costs, therefore reducing complaints via investments in “better buildings” would have a relatively straightforward business case.

Conclusions

This literature synthesis demonstrated that better buildings strategies (e.g. improved ventilation, enhanced lighting conditions, green building certification measures) provide benefits to multiple organizational productivity metrics at levels similar to other popular corporate strategies that are implemented at the employee level. This supports the greater consideration by HR and corporate decision-makers of better buildings strategies as measures to improve organizational productivity.

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** Denotes papers from the literature review that contributed to the conclusions in Table 2.*

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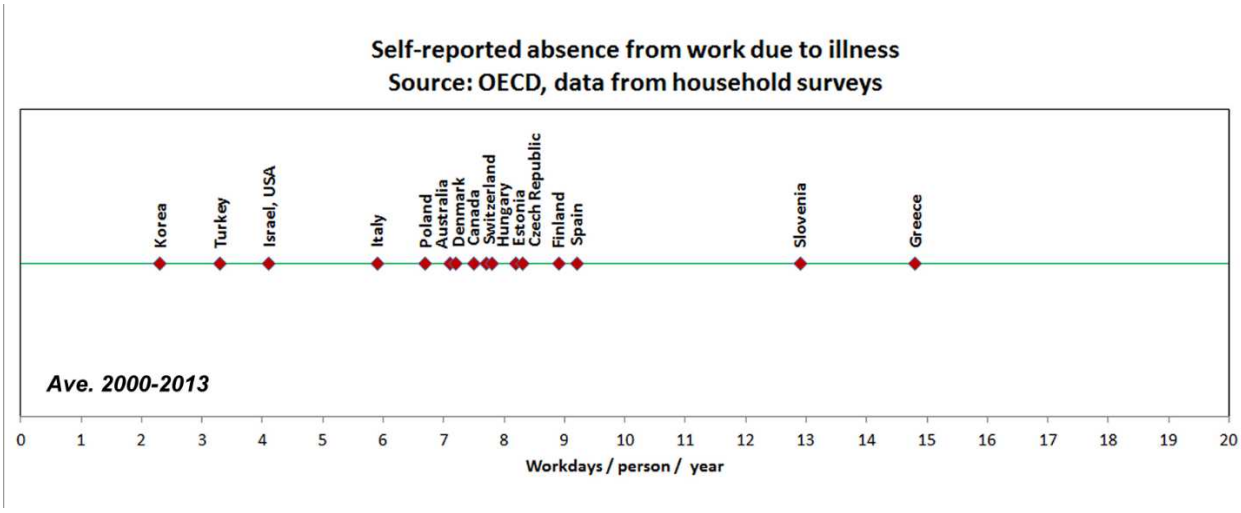

Figure 1

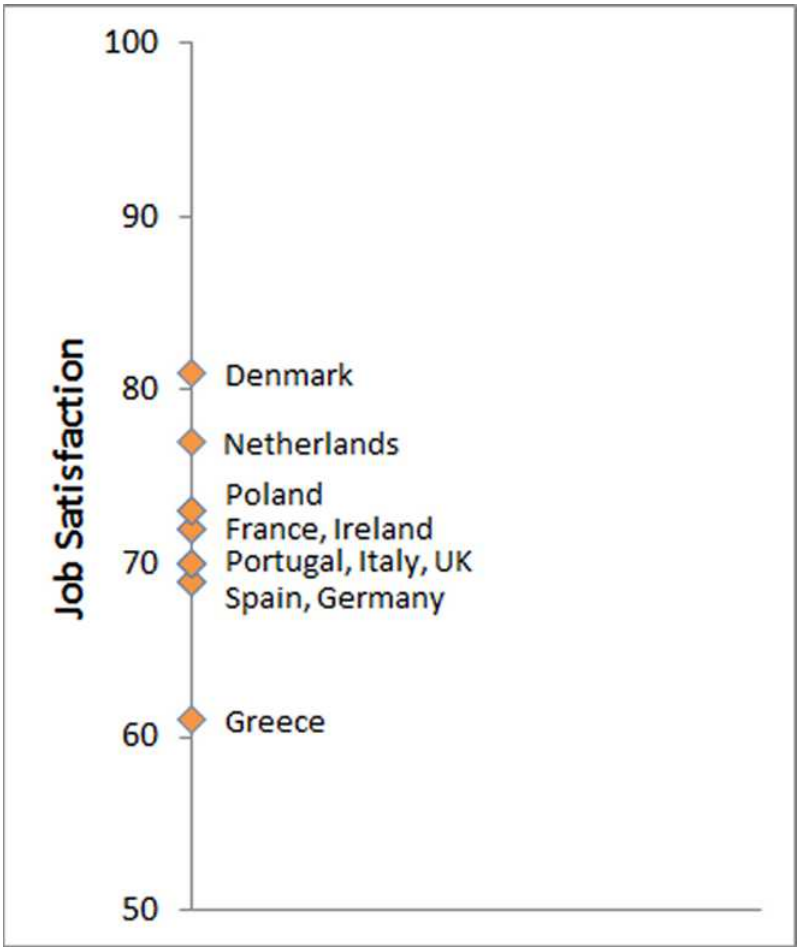

Figure 2

Table 1. The number of publications considered as source material. The upper number in each cell is an estimate of the number of abstracts obtained from keyword searches. If the abstracts looked promising, the full publication was reviewed for relevance. The lower number in each cell is an estimate of the number of full papers examined.

	Better Buildings	Office Type	Workplace Health Programs	Bonuses	Flexible Work Options
Absenteeism	250 30	200 30	70 35	646 20	145 10
Employee Turnover	200 15	150 20	190 15	10 10	50 10
Perceived Performance	200 45	150 26	140 20	120 34	100 17
Job Satisfaction	200 25	160 32	70 25	490 16	50 10
Health	200 35	150 22	140 30	100 10	20 10
Facility Complaints	100 20	-	-	-	-

	Strategies (IV)➔	Better Buildings	Office Type (Private --> Open)	Workplace Health Programs	Bonuses	Flexible Work Options	
Benchmarks	**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
	Complaints to FM						

Table 2. Results summary showing the benchmarks associated with each metric, and the direct effects of various corporate strategies. The benchmark has a dark grey 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; this is often a range covering effects from multiple studies. An arrow without a number indicates that the direction of the effect is established, but a size was not derivable from the published studies.

Table 3. Absenteeism data for Canada, by major industry.

Canada by Industry Sector (2015)	Illness or disability (days/person/yr)
Professional, scientific, & technical services	3.5
Real estate and rental and leasing	4.8
Finance and insurance	6.6
Business, building & support services	7.5
Public administration	10.7

Table 4. Overall health (rescaled to 0-100) for OECD countries.

New Zealand	76.2	United Kingdom	69.6	Slovak Rep.	66.2
Canada	75.8	Denmark	69.3	Slovenia	66.2
United States	75.3	Luxembourg	69.1	Italy	66.1
Australia	74.5	Greece	69.0	Chile	65.8
Ireland	73.5	Spain	68.9	Czech Rep.	64.0
Sweden	73.1	Israel	68.0	Poland	63.2
Switzerland	73.1	Austria	67.9	Hungary	62.3
Iceland	71.2	France	67.6	Estonia	61.3
Netherlands	71.1	Finland	67.4	Portugal	58.3
Norway	70.4	Germany	67.0	Japan	55.8
Belgium	69.7	Turkey	66.8	Korea	55.7
				OECD	**68.2**

Appendix A. Literature Search Details

Searches encompassed the title, keywords, and abstracts of database entries. The terms are expressed in standard database search format. * = wildcard character, meaning it can be replaced by any character or string of characters (e.g. control* = control, controls, controller, controlling etc). w/1 separating two words in the search term will find articles where these two words appear within one word of each other in a publication; w/2 within two words of each other, etc.

Table A1. List of search terms used for corporate strategies and KPIs

Corporate Strategies

- Better buildings
  - Green buildings
  - LEED
  - Healthy Buildings.
  - building w/2 automation
  - thermal w/2 comfort
  - personal w/2 control*
  - individual w/2 control*
  - green w/2 building*
  - humidity*
  - lighting
  - ieq / iaq / ventilation/ hvac
  - indoor w/1 air
  - indoor w/1 environmental
  - dayligh*

Ergonomic Improvements

- ergonom*
  - standing desk*
  - human W/1 factor* W/1 design*
  - workstation* OR "work station*"
  - musculoskeletal W/1 prevention
  - office w/2 layout
  - office w/2 design*
  - Bonuses
- bonus* / remuneration
  - economic w/2 incentive*
  - monetary w/2 incentive*
  - financial w/2 incentive*
    - rewards
    - merit
    - contingent pay
  - Flexible work options
- Work from home
  - flexible W/2 work
  - flexible W/2 hours
  - Flexible W/2 schedule*
  - Flexible W/2 time / flexi-time / flextime
  - Telecommuting
  - Job sharing
  - Workplace Health Programs or Fitness Options

KPIs

- Absenteeism
  - Attendance
  - "sick leave"
  - leave
  - Absence*
  - Illness OR sickness
- Facility Complaints
  - complaints w/3 (building* or manager or operations or)
  - building operations
  - complaints OR crowding OR noise OR discomfort OR grievance
- Employee Turnover
  - retention
  - turnover
  - voluntary
  - retir*
  - resignation
- Satisfaction
  - productivity OR efficiency
  - satisfaction
  - fulfilment
  - self-realiz* OR self-actual*
- Health
  - well-being, wellbeing
  - health
  - wellness
  - symptoms
  - sick building syndrome, SBS
- Individual Performance
  - productivity
  - cognitive performance
  - work/job/task performance

- Workplace Health Programs
    - Fitness
    - Stairway / steps / stairs / step challenge
    - Walkability or walks or pedometers or walking
    - Activity breaks OR physical activity OR physical fitness
    - Gyms / gymnasium / fitness facilities / onsite fitness
    - Transit options, bike-sharing
    - Yoga or sports or running or biking or skiing
    - Biking or cycling or transit options
    - Stretch breaks
    - Lockers, showers, bike racks
    - Reimbursement or incentives for gym membership
    - Discounted gym memberships
    - Health food / Nutrition healthsmart, garden market
    - Diet, weight control / weight W/2 program*
    - Paramedical Services – massage
    - Stress management
    - Workplace intervention
    - Mental fitness activities mental health
    - Programs – weight control / smoking / alcohol
    - Stress reduction
    - Lactation Support Program
    - Smoking cessation
    - Screening days – breast cancer, prostate etc.
    - The National Work Life Program – mental health support / screening
    - UV prevention or UV screening

Appendix B. Translating study results to Common Scales

The translation of survey data to common 0-100 scales relied on a somewhat arbitrary attachment of a value to adjectives describing degree of response. For example, when asked about the likelihood of looking for a new job on the University of Chicago General Social Survey "very likely" was numerated as 80 because more extreme adjectives are available (e.g. "extremely", "exceedingly") and may have been used in other studies, even though "very" was the end point of the specific study in question. Nevertheless, changing these numerical assignments by reasonable amounts would not affect the major conclusions in this paper.

In additions, a formal rescaling exercise would have included consideration of the variability in responses from each data set. However, we did not have access to necessary variability information in many cases.

Given these limitations, the rescaled information should be considered as providing "rule of thumb" guides to facilitate comparisons between disparate studies in multiple disciplines. This may encourage the convergence of scale choices and reporting standards in the future.

B.1 Intent to turnover

In the University of Chicago General Social Survey the question asked was: "Taking everything into consideration, how likely is it you will make a genuine effort to find a new job with another employer within the next year?" (http://www.cdc.gov/niosh/topics/stress/pdfs/qwl2010.pdf, Q 5.63), with a three-point response scale. Shown below is the distribution of the responses, and the assignment of the response labels to the normalized 0-100 scale. The weighted mean score is then =

((2818*0)+(969*40)+(831*80))/(2818+969+831) = 23.

Scale	Not at all likely				Somewhat likely				Very likely		
0-100	0	10	20	30	40	50	60	70	80	90	100
Frequency	2818				969				831		
Mean Score	**23**										

In the University of Michigan Work, Family, and Health Study two questions were relevant: "You are seriously considering quitting ^FCOMPANY for another employer" and "During the next 12 months, you will probably look for a new job outside ^FCOMPANY" (http://www.icpsr.umich.edu/cgi-bin/file?comp=none&study=36158&ds=0&file_id=1190655&path=DSDR), each with a five-point response scale. The mean response to these two questions was used. Shown below is the distribution of the responses, and the assignment of the response labels to the normalized 0-100 scale. The weighted mean score is then = ((2439*0)+(744*13)+(2401*25)+(928*38)+(1184*50)+(572*63)+(469*75)+(170*88)+(241*100)/(2439+744+2401+928+1184+572+469+170+241 = 30.

Scale	Strongly		Disagree		Neither		Agree		Strongly Agree
0-100	0	13	25	38	50	63	75	88	100
Frequency	2439	744	2401	928	1184	572	469	170	241

Mean Score	**30**								

In the Japanese General Social Survey the question asked was: "Are you considering quitting your current job (your business)?" (http://www.icpsr.umich.edu/cgi-bin/file?comp=none&study=34623&ds=1&file_id=1182229&path=ICPSR; WLKEEPJA), with a three-point response scale. Shown below is the distribution of the responses, and the assignment of the response labels to the normalized 0-100 scale. The weighted mean score is then = ((1465*0)+(1319*30)+(213*70))/(1465+1319+213) = 18.

Scale	I am not considering			I am not considering				I am considering quitting			
0-100	0	10	20	30	40	50	60	70	80	90	100
Frequency	1465			1319				213			
Mean Score	**18**										

In Newsham et al. (2013) three questions were asked: "I am planning to search for a new job outside of this organization during the next 12 months", "I often think about quitting this job", "If I have my own way, I will be working for this organization one year from now", each with a seven-point response scale, from "Strongly Disagree" to "Strongly Agree". This review used the mean response to these three questions (final question reverse coded), coding "Strongly Disagree"=0, and "Strongly Agree"=100.

The mean value of the mean responses from all individuals was 2.69 on a 1-7 scale, or 28 on the 0-100 scale.

Appendix B2. Job satisfaction

In the University of Chicago General Social Survey the question asked was: "All in all, how satisfied would you say you are with your job?", with a four-point response scale. Shown below is the distribution of the responses, and the assignment of the response labels to the normalized 0-100 scale. For example, the weighted mean score for 2014 is then = ((36*0)+(87*30)+(505*60)+(615*80))/(36+87+505+615) = 66.

Year	Mean score	Scale	Not at all			Not too			Somewhat		Very		
		0-100	0	10	20	30	40	50	60	70	80	90	100
2002	66	**Freq.**	61			134			707		872		
2006	65	**Freq.**	55			110			770		786		
2010	65	**Freq.**	40			94			503		524		
2014	66	**Freq.**	36			87			505		615		

In the University of Michigan Work, Family, and Health Study three questions were relevant: "In general, you like working at your job", "In general, you are satisfied with your job", "You are generally satisfied with the kind of work you do in this job", each with a five-point response scale. This review used the mean response to these three questions. Shown below is the distribution of the responses, and the assignment of the response labels to the normalized 0-100 scale. The weighted mean score is then = ((20*0)+(18*8)+(25*16)+(108*25)+(98*33)+(201*41)+(313*50)+(639*58)+(799*66)+

(3213*75)+(979*83)+(798*91)+(1977*100)/(20+18+25+108+98+201+313+639+799+3213+979+798+1977 = 78.

Scale	Strongly			Disagree			Neither			Agree			Strongly
0-100	0	8	16	25	33	41	50	58	66	75	83	91	100
Frequency	20	18	25	108	98	201	313	639	799	3213	979	798	1977
Mean Score	**78**												

In the Japanese General Social Survey the question asked was: "On the whole, how satisfied are you with the (main) job you have?", with a five-point response scale. Shown below is the distribution of the responses, and the assignment of the response labels to the normalized 0-100 scale. The weighted mean score is then = ((82*0)+(228*30)+(719*50)+(1231*70)+(812*90))/(82+228+719+1231+812) = 66.

Scale	Dissatisfied			Somewhat dissatisfied		Neither satisfied nor dissatisfied		Somewhat satisfied		Satisfied	
0-100	0	10	20	30	40	50	60	70	80	90	100
Frequency	82			228		719		1231		812	
Mean Score	**66**										

The data from Europe was a single question referring to the respondent's opinion/feeling about the degree of satisfaction with his/her job (http://ec.europa.eu/eurostat/documents/1012329/6071326/2013_Module_Well-

being.pdf/93ac2517-f6ac-4ed5-8c42-ca89568ea5c9). Response was on an 11-point scale, from 0 (Not at all satisfied) to 10 (Completely satisfied). Multiplying the mean values from each country by 10 scaled responses to the 0-100 scale.

In Newsham et al. (2013) a single question was asked: "Taking everything into consideration, what is your degree of satisfaction with your job as a whole?", with a seven-point response scale, from "Very Unsatisfactory" to "Very Satisfactory". The conversion coded "Very Unsatisfactory"=0, and "Very Satisfactory"=100. The mean value of the responses from all individuals was 5.60 on a 1-7 scale, which equates to 77 on the 0-100 scale.

In Veitch, et al., (2007) a single question was asked: "Please indicate your degree of agreement or disagreement with the following statement … I am satisfied with my job", with a seven-point response scale, from "Very Strongly Disagree" to "Very Strongly Agree"=100. The mean value of the responses from all individuals was 5.09 on a 1-7 scale, which equates to 68 on the 0-100 scale.

Appendix B3. Health Symptoms

In Hongisto et al. (2016) five specific symptoms (throat symptoms; eye symptoms; nasal symptoms; headache; stress) were each assessed on a five-point frequency scale: "1=Never", "2=Only rarely", "3=Sometimes", "4=Often, "5=Very often". The mean symptom scores on the original scale prior to the intervention were: throat symptoms=3.5; eye symptoms=3.0; nasal symptoms=3.1; headache=3.1; stress=3.5. If one numerates the scale end-points at 0 and 90, then average scores for the symptoms ranged from 45 (eye) to 56 (throat, stress). For example, to calculate the score for throat symptoms = ((90-0)/(5-1))*(3.5-1) = 56.

In Newsham, et al. (2013) participants self-reported on eleven symptoms in two categories: visual discomfort and physical discomfort. Each symptom was assessed for frequency on a five-point scale: “1=Never”, “2=Very rarely”, “3=Monthly”, “4=Weekly”, “5=Daily”. The mean symptom scores on the original scale prior to the intervention were: visual symptom frequency=2.48; physical=2.60. If one numerates the end-points of the scale at 0 and 80, then scores for the symptoms in the conventional building sample (N=480) ranged from 30 (visual) to 32 (physical). For example, to calculate the score for physical symptom frequency = ((80-0)/(5-1))*(2.60-1) = 32.

Appendix C. Details of studies used to derive effects of corporate strategies on outcomes linked to organizational productivity

Study	Location	Sample Size	Manipulation	Effect (days/pers/yr)	Notes
Absenteeism: Effect of Better Buildings					
Milton, Glencross, and Walters (2000)	large US manufacturer	>600	outdoor air supply rate 24 l/s/pers vs.12 l/s/pers	1.2 – 1.9 lower	Current ASHRAE minimum recommended outdoor air rate is 8.5 l/s/pers. The authors note that this was an effect size similar to a flu vaccination.
Niemela, Seppanen, Korhonen, and Reijula (2006)	insurance company in Finland	~45	cleaning the ventilation system, replacement of duct lining, and air flow balancing	0.65 lower	Associated with a reduction in reported health symptoms (no statistical tests were reported).
Veitch, Newsham, Mancini and Arsenault (2010)	large office buildings in Canada	>1000	direct-indirect electric lighting with personal dimming control allied with new office furniture (lower, lighter-coloured panels) vs. direct parabolic luminaires with older office furniture (higher, darker-coloured panels)	0.4 lower	
Singh, Syal, Korkmaz, and Grady (2011)	US office workers	56 (pre), 207 (post)	move from conventional buildings to green (LEED certified) buildings		Statistically-significant, though small improvements post-move were demonstrated, but specific to employees with certain medical conditions.
Preller, Zweers, Brunekreef, and Boleij (1990)	Dutch office workers	~5000	cross-sectional study applied to 17 building characteristics		Results presented as odds-ratios. Suggests other building characteristics did not have statistically-significant effects, but data not shown.
Absenteeism: Effect of Office Type					
Pejtersen, Feveile, Christensen, and Burr (2011)	office employees in Denmark	2403	Private offices vs. open-plan offices with more than six occupants	3.2 lower	Any office with more than one occupant associated with higher sick leave. Suggested mechanisms for increased sick leave include: greater noise exposure, virus transmission, loss of privacy/autonomy, access to window, natural ventilation
Bodin Danielsson, Chungkham, Wulff, & Westerlund (2014)	office employees in Sweden	1852	Private offices vs. open-plan offices		Overall trend was for open-plan spaces to have a higher risk of sick leave.
Absenteeism: Effect of Workplace Health Programs					
Baicker, Cutler, and Song (2010)	focus on US workplaces	meta-analysis of 22 studies		1.8 lower	
Kuoppala, Lamminpaa, and Husman (2008)		Review of 46 studies, seven in offices			Authors concluded “There is moderate evidence that work health promotion decreases sickness absences”

Marzec et al. (2011)	US state public-sector workers	404	An offering of 13 health and well-being oriented interventions	0	
Absenteeism: Effect of Bonuses					
Pfeifer (2014)	German managers	177	higher achievable bonus payments	1 lower	Base salary not significantly correlated with absence; effect of bonus estimated from published information.
Absenteeism: Effect of Flexible Work Options					
Whyman and Petrescu (2015)	small and medium-sized enterprises in the UK	135 companies	Home or mobile working Family-friendly practices	2.5 higher 2.8 lower	
Dionne and Dostie (2007)	Canada		various work arrangements, including working from home, and flexible hours		Many statistically-significant effects in both directions, but effects were small, and of little practical significance.

Table C1. Effects on absenteeism

Study	Location	Sample Size	Manipulation	Effect (0-100)	Notes
Employee turnover: Effect of Better Buildings					
Veitch et al. (2010)	large office buildings in Canada	>1000	direct-indirect electric lighting with personal dimming control allied with new office furniture (lower, lighter-coloured panels) vs. direct parabolic luminaires with older office furniture (higher, darker-coloured panels)	1.3 lower	
Employee turnover: Effect of Office Type					
Newsham, et al. (2013)	office buildings in Canada and northern US	48	private offices vs. open-plan offices	18 lower	Sub-set in which survey and physical data were available from the same workstations in conventional buildings.
Oldham and Fried (1987)	clerical staff in a large US university	109			"… Employees were most likely to withdraw from offices and to experience dissatisfaction with their work when the following conditions were present simultaneously: the office was rated as dark, few enclosures surrounded employees' work areas, employees were seated close to one another, and many employees occupied the office."
Employee turnover: Effect of Workplace Health Programs					
Caillier (2016)	US federal agencies	240		0	Analysis focussed on those seeking another job outside government.
Employee turnover: Effect of Bonuses					
Park and Sturman (2016)	US service-sector	720			Merit pay had strongest negative association with employee turnover, followed by long-term incentives, whereas bonus pay increased employee turnover. Overall, effects were greatest for higher performing staff.
Salamin and Hom (2005)	Swiss banks	11,098			Merit pay increases and bonuses were associated with sizable reductions in quit rates, and effects were greatest for higher performing staff.
Nyberg (2010)	US insurance companies	12,545			Both higher total compensation, and employee perception that higher performance was rewarded, associated with lower turnover rates. Effects greatest for higher performing staff.
Employee turnover: Effect of Flexible Work Options					
No relevant studies were identified					

Table C2. Effects on employee turnover

Study	Location	Sample Size	Manipulation	Effect (%)	Notes
Self-assessed performance: Effect of Better Buildings					
Singh et al. (2011)	US office workers	86	move from conventional buildings to green (LEED certified) buildings	2 higher	
Agha Hossein, El-Jouzi, Elmualim, Ellis, and Williams (2013)	private-sector staff in the UK	160 (pre), post (183)	move from older building to structurally similar, newly refurbished (BREEAM "Very Good" rating), building next-door	5 higher	Employees asked to what extent they agreed with: "My current office environment already has a positive effect on my productivity", with a 5-point scale ("strongly disagree" to "strongly agree"). Assume this spans same +30% to -30% scale as Wilson & Hedge (1987)
Baird, Leaman, and Thompson (2012)	worldwide		Comparison of building average data from sustainable (N=31) and conventional buildings (N=109)	7.8 higher	
Thomas (2010)	Australia	167 (pre), 238 (post)	Move from conventional building to refurbished building (highest rating under the Green Star – Office Interiors system (http://new.gbca.org.au/green-star/)).	9.6 higher	
Oseland and Burton (2012)	UK public sector	1,420	recently-built bldg. vs. 1950s legacy bldg.. newest bldg. vs. 1950s legacy bldg..	2.2 higher 4.8 higher	
MacNaughton et al. (2017)	US	109	Green vs. matched conventional buildings		Participants in green bldgs scored 26.4% higher on cognitive function tests than those in conventional bldgs.
Self-assessed performance: Effect of Office Type					
Newsham, et al., (2013)	office buildings in Canada and northern US	228	private offices vs. open-plan offices	7.7 higher	Sub-set of larger data set.
Bergstrom, Miller, and Horneij (2015)	Sweden	21	private offices (pre-move) to open-plan offices	8.1 higher	Assessed using 20 questions, with a 100-point scale. After reverse coding, mean responses were 56.0 (private) and 47.9 (open-plan). Range and size of the effect is consistent with other studies, so difference interpreted on same scale.
Brennan et al. (2002)	Canada, private sector	21	mostly private offices (pre-move) to mostly shared/open-plan	13.0 higher	Assessed as in Bergstrom, Miller, and Horneij (2015), with the same coding an interpretation.
Lee (2010)	LEED-certified buildings in North America	3533	Private offices vs. high-panel cubicle offices	14.6 higher	Participants asked "Does the office layout enhance or interfere with your ability to get your job done?", with a 7-point response scale (enhances (+3) to interferes (-3)); seems directly scaled to the +/-30%. Private offices had higher scores than all types of shared/open offices.
Self-assessed performance: Effect of Workplace Health Programs					

Coffeng et al. (2014)	European financial services company	412		5-10 higher	Work performance assessed with the Individual Work Performance Questionnaire (IWPQ), 5-point scale. Mean self-rating increased from 3.3 to 3.7 post-WHP intervention. Translating to the percentage scale not straightforward, and table value is an estimate.
Rongen, Robroek, van Lenthe, and Burdorf (2013)		meta-analysis including five studies in offices			Two studies included a productivity measure: one showed a significant positive effect of a WHP, the other showed no effect.
Vuokko et al. (2015)	Finland	43 (asthma sufferers)		0	
Blake, Zhou, and Batt (2013)	UK National Health Service	1134		0	
Pereira, Coombes, Comans, and Johnston (2015)		review of three studies		0	
Self-assessed performance: Effect of Bonuses					
Lowery, Petty, and Thompson (1995)	US utility	~8000	Employees received a bonus up to 20% for superior performance, rated by their manager		Across all employee categories, 70% agreed that the bonus plan had a positive effect on their work habits and performance, but only 47% agreed that it had improved their personal productivity; nevertheless, 70% agreed that it had improved the company's performance.
Stajkovic and Luthans (2001)	Financial sector	186			Simple bonuses for increased performance were associated with a performance improvement of 11%; bonuses with a formal process to identify organizational deficiencies increased performance by 32%.
O'Neill (2014)	call centre in Mexico	168			A small bonus awarded for every sale of a specific type. When the bonus was removed, there was a decrease in sales of 22.4%.
Garbers and Konradt (2014)		meta-analysis of 116 studies			Effect was statistically significant, and positive. Data from multiple settings; office-like environments were not separated. Effects larger for more complex tasks.
Self-assessed performance: Effect of Flexible Work Options					
No relevant studies were identified					

Table C3. Effects on self-assessed performance

Study	Location	Sample Size	Manipulation	Effect (0-100)	Notes
Job satisfaction: Effect of Better Buildings					
Veitch et al. (2010)	large office buildings in Canada	>1000	direct-indirect electric lighting with personal dimming control allied with new office furniture (lower, lighter-coloured panels) vs. direct parabolic luminaires with older office furniture (higher, darker-coloured panels)	6 higher	
Hongisto, Haapakangas, Varjo, Helenius, and Koskela (2016)	call centre workers in Finland	40	better environmental conditions (e.g. sound absorption, odour mitigation) and control (e.g. personal light switches), increased privacy, and more ergonomic furniture	4 higher	Job satisfaction assessed via a single item on a pre-post questionnaire, “How satisfied are you with your work as a whole?”, with a five-point scale from “Very dissatisfied” to “Very satisfied”, which was numerated 10-90.
Agha Hossein et al. (2013)	private-sector staff in the UK	160 (pre), post (183)	move from older building to structurally similar, newly refurbished (BREEAM “Very Good” rating), building next-door	9 higher	Employees asked to what extent they agreed with: “My current office environment already has a positive effect on my enjoyment at work”, using a five-point scale from “strongly disagree” to “strongly agree”, which was numerated from 10-90.
Newsham, et al. (2013)	office buildings in Canada and northern US		Green buildings vs. matched conventional buildings	0	Analysis at building average level (18 sites in total)
Job satisfaction: Effect of Office Type					
Bergstrom et al. (2015)	Sweden	21	Private offices (pre-move) to open-plan offices	10 higher	Measure was “Internal work experience”, the sum of responses to six items on a six-point scale, with outcome range of 6-36, which was rescaled to 0-100.
Pejtersen et al. (2011)	office employees in Denmark	2403	Private offices vs. open-plan offices with more than six occupants	4.7 higher	Sum of responses to four items, on a 0-100 scale. There was a systematic decline from single-person offices to offices shared with increasing numbers of people.
Bodin Danielsson and Bodin (2009)	Sweden	469	Private offices vs. large open-plan offices		One item asked whether “the workspace design did not contribute to job satisfaction." 31% of occupants of private offices agreed, compared to 64% in large open-plan offices.
De Croon, Sluiter, Kuijer, and Frings-Dresen (2005)		Review of 49 studies			Concluded that “… working in open workplaces reduces privacy and job satisfaction.” Review included Oldham and Fried (1987).

Job satisfaction: Effect of Workplace Health Programs					
Caillier (2016)	US federal agencies	240		12 higher	Two items: “Considering everything, how satisfied are you with your job?” and “Considering everything, how satisfied are you with your organization?” Scales ranged from 1 (strongly disagree) through 5 (strongly agree). These labels were numerated as 10-90.
Conn, Hafdahl, Cooper, Brown, and Lusk (2009)		meta-analysis of 17 studies			An overall, statistically-significant positive effect reported for one research design type (two-group pre-post) but not for two others (two-group post-test, treatment pre-post). Results not reported for office work separately.
Marzec et al. (2011)	US state public-sector workers	404	An offering of 13 health and well-being oriented interventions	0	One of 15 factors on the University of Michigan Health Management Research Center’s Health Risk Appraisal.
Blake et al. (2013)	UK National Health Service	1134		~0	Statistically-significant improvement, but size of effect was very small.
Job satisfaction: Effect of Bonuses					
Lowery et al (1995)	US utility	~8000	Employees received a bonus up to 20% for superior performance, rated by their manager		Across all employee categories, only 46% agreed that the bonus plan had a positive effect on their job satisfaction, although the figure was 61% for managers.
Job satisfaction: Effect of Flexible Work Options					
Fonner and Roloff (2010)		89 (teleworkers), 103 (office)	Compared those who mostly worked remotely, with workers who mostly worked in an office environment	10.3 higher	Mean of responses to five items, each on a seven-point scale; rescaled (1=0 to 7=100).
Caillier (2016)	US federal agencies	240	Telework, flex-time	0	
Nijp, Beckers, van de Voorde, Geurts, and Kompier (2016)	Dutch financial company	361 (NWW), 80 (control)	New ways of working (NWW) environment which provided both temporal and spatial flexibility in work patterns	0	A single item, “Indicate how satisfied you generally are with your work”, on a 10-point scale: “very dissatisfied” (0) to “very satisfied” (10); rescaled with 10 multiplier. Following implementation, there was a large shift in work hours towards teleworking.

Table C4. Effects on job satisfaction

Study	Location	Sample Size	Manipulation	Effect (0-100)	Notes
Health and well-being (symptoms): Effect of Better Buildings					
Hongisto et al. (2016)	call centre workers in Finland	40	better environmental conditions (e.g. sound absorption, odour mitigation) and control (e.g. personal light switches), increased privacy, and more ergonomic furniture	4 – 9 lower	Statistically-significant reduction in throat symptoms. Mean frequencies were reduced for all other symptoms.
Newsham et al. (2013)	office buildings in Canada and northern US		Green buildings vs. matched conventional buildings	7 lower (visual) 5 lower (physical)	Analysis at building average level (18 sites in total)
MacNaughton et al. (2017)	US	109	Green vs. matched conventional buildings		Participants in green buildings reported 30% fewer sick building syndrome symptoms. Participants in green buildings also reported better sleep quality, and a similar association was observed in Newsham et al. (2013).
Marmot et al. (2006)	UK civil servants	4052	Greater workstation control (ability to adjust heat, artificial light, to open the window, and fewer than 10 people in the room)		Statistically-significant reduction in symptoms.
Fisk et al. (2009)	Office buildings	17 – 1306	Ventilation rate		Outcome was symptom prevalence, not frequency. Synthesis of eight published studies. Prevalence measured in many different ways, including different symptom checklists, different timeframes. On average, statistically-significant reduction in prevalence as ventilation rates increased.
Health and well-being (symptoms): Effect of Office Type					
Pejtersen Allermann, Kristensen, and Poulsen (2006)	Denmark	2301	private offices vs. large open-plan offices		Of 14 symptom types, all but two had a statistically-significant lower report frequency in private offices.
Herbig, Schneider, and Nowak (2016)	German insurance companies	207	private offices vs. open-plan offices		Cumulative complaints measure (exhaustion, stomach, musculoskeletal, and heart complaints), on a five-point scale: 1 (none) to 5 (strong). Reporting precluded conversion to a 100-point scale; working in a private office associated with lower complaints (1.55 vs. 1.93).
Health and well-being (symptoms): Effect of Workplace Health Programs					
No relevant studies were identified.					
Health and well-being (symptoms): Effect of Bonuses					
No relevant studies were identified.					
Health and well-being (symptoms): Effect of Flexible Work Options					
No relevant studies were identified.					

Table C5. Effects on health and well-being (symptoms)

Study	Location	Sample Size	Manipulation	Effect (0-100)	Notes
Health and well-being (overall): Effect of Better Buildings					
Baird et al. (2012)	worldwide		Comparison of building average data from sustainable (N=31) and conventional buildings (N=109)	10 higher	Respondents asked: “Do you feel less or more healthy when you are in the building?” on a seven-point scale. Mean scores: conventional buildings 3.29, sustainable buildings 4.25. The scale endpoints were numerated as +/- 30% (somewhat arbitrary, based on the self-reported productivity scale used in the same study).
Agha Hossein et al. (2013)	private-sector staff in the UK	160 (pre), post (183)	move from older building to structurally similar, newly refurbished (BREEAM “Very Good” rating), building next-door	6 higher	Employees were asked: “My current office environment already has a positive effect on my well-being” on a five-point scale from “strongly disagree” to “strongly agree”. Mean scores: old office -0.18, newly refurbished office 0.25. It was assumed that this spans the +/- 30% scale.
Health and well-being (overall): Effect of Office Type					
Bergstrom et al. (2015)	Sweden	21	Private offices (pre-move) to open-plan offices	12 higher	Salutogenic Health Indicator Scale that included ratings of twelve health indicators on a six-point scale. Outcome range of 6-72 linearly rescaled to a 100-point scale.
Herbig et al. (2016)	German insurance companies	207	private offices vs. open-plan offices	11 higher	Mental well-being measured with the World Health Organization Well-being Index, which includes five items on a six-point scale: 1 (at no time) to 6 (all of the time).
Pejtersen et al. (2006)	Denmark	2301	private offices vs. large open-plan offices	0	Single items on general health and mental health, each on a 0-100 scale.
Seddigh, Berntson, Bodin Danielson, and Westerlund (2014)	Sweden	1241	private offices vs. open-plan offices	0	A single item measured general health: “How would you judge the state of your general health?” on a five-point scale (1=very poor, 5=very good). Cognitive stress measured with Copenhagen Psychosocial Questionnaire, on a five-point scale (1= never, 5=always). No effect of office type on general health, but private offices associated with lower cognitive stress (2.45 vs. 2.81).
Health and well-being (overall): Effect of Workplace Health Programs					
Butterworth, Linden, McClay, and Leo (2006)	US health care centre workers	88			Two composite outcome scores from 12 questions: the Mental (MCS) and Physical Composite Score (PCS), each on 0-100 point scale. No effect for PCS, but a significant improvement of 3.5 points on MCS.
Marzec et al. (2011)	US state public-sector workers	404	An offering of 13 health and well-being oriented interventions	0	Data for 15 factors on Health Risk Appraisal. No effect on self-reported health or stress; there was a reduction in life dissatisfaction, but an increase in blood pressure.

Kuoppala et al. (2008)		Review of 46 studies, seven in offices			Results not expressed in units scalable to the needs of this paper, and were not isolated by office environments only. The authors concluded that work health promotion had no effect on physical well-being.
Rongen et al. (2013)		meta-analysis including five studies in offices			Two studies included a measure of general health. One of these showed a significant positive effect of a WHP, whereas the other showed no effect.
Vuokko et al. (2015)	Finland	43 (asthma sufferers)	Finland	0	Included the RAND quality of life survey, scored on a 100-point scale, with physical and mental components.
Blake et al. (2013)	UK National Health Service	1134		0	General health rated on a six-point scale (0=very poor to 5= excellent). The 12-item General Health Questionnaire used to measure mood.
Health and well-being (overall): Effect of Bonuses					
No relevant studies were identified					
Health and well-being (overall): Effect of Flexible Work Options					
Nijp et al. (2016)	Dutch financial company	361 (NWW), 80 (control)	New ways of working (NWW) environment which provided both temporal and spatial flexibility in work patterns	6 lower	Ten-point scales used to assess health (1=very bad, 10=very good), and stress (1=very little stress, 10=very much stress). Fatigue measured with three items on a four-point scale (1=almost never, 4=almost always). No meaningful effects of on fatigue, or stress.

Table C6. Effects on health and well-being (overall)

[i] For extensive detail, see Newsham et al. (2017).

[ii] For example, the OECD (http://www.oecd.org/health/health-data.htm, click on "Definitions, Sources and Methods", "Self-reported absence from work due to illness".

[iii] They also noted that occupants of private offices are more likely to have access to natural ventilation via a window, which, regardless of the resulting outdoor air rates and pollutant sources, is an extra factor of personal control, which is generally desired by office workers.

[iv] They also concluded that absenteeism costs fall by about US$2.73 for every dollar spent on WHPs.

[v] http://gss.norc.org/. NIOSH supplement: http://www.cdc.gov/niosh/topics/stress/qwlquest.html).

[vi] The main effect of building type showed green buildings to be 4% higher on average. This effect was not statistically significant (p=0.09), but the magnitude is consistent with the effect sizes in the other "better buildings" studies in the previous sub-section.

[vii] e.g. http://www.gallup.com/topic/employee_engagement.aspx