


Remote Work, Work Measurement and the State of Work Research in Human-Centred Computing

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Abstract

Over the past few decades, a small but growing group of people have worked remotely from their homes. With the arrival of the coronavirus pandemic, millions of people found themselves joining this group overnight. In this position paper, we examine the kinds of work that ‘went remote’ in response to the pandemic, and consider the ways in which this transition was influenced by (and in turn came to influence) contemporary trends in digital workplace measurement and evaluation. We see that employers appeared reluctant to let certain classes of employee work remotely. When the pandemic forced staff home, employers compensated by turning to digital surveillance tools, even though, as we argue, these tools seem unable to overcome the significant conceptual barriers to understanding how people are working. We also observed that, in the United Kingdom context, the pandemic *didn’t* mean remote work for a significant proportion of the population. We assert that, to maximize its impact, ‘future of work’ research in human-centred computing must be more inclusive and representative of work, rather than focusing on the experiences of knowledge workers and those involved in new forms of work.

RESEARCH HIGHLIGHTS:

- We show that, prior to the pandemic, remote work seems to have been a perk withheld from lower paid staff in positions with less power.
- We explore how employers tried to monitor newly-remote workers once remote work was mandated by governments during Covid-19 pandemic lockdowns.
- Given our reflections on changes to work during the pandemic, we ask whether work research in human-centred computing should be doing more to reflect the variety in work and workplaces.
- We make suggestions for broadening the range of work research in human-centred computing, with a view to increasing impact.

Keywords: bossware, tracking, productivity, remote work, the future of work, work

1. INTRODUCTION

The potential benefits of remote work (or ‘telecommuting’) were being discussed by academics well before mainstream adoption of internet connections at home (Nilles, 1988). News media has reported on the demise of the traditional office for some time, too (Ward, 2005). In reality, the growth of remote work has been slow and the number of people working remotely on a regular basis has been small (Handy and Mokhtarian, 1996; Felstead, 2012). Of course, this changed with the arrival of the coronavirus pandemic that upended work for hundreds of millions of people across the world.

With the imposition of ‘lockdowns’ in 2020 that required people across the world to stay at home, many people became remote workers overnight. This kind of mass transition as a single event is unprecedented, but it has also taken place in the context of larger changes to the nature of work and workplaces, most especially the digitization of work and increasing use of workplace tracking technologies (Lloyd, 2022).

The goal of this paper is to connect the acute changes to work created by the pandemic with the broader trends in the use of technology for the measurement and evaluation of work. To do this, we look at how different classes of workers were affected by the move to remote work and examine these effects in the historical context of remote work. We link these changes to the way that work is measured and evaluated using digital technology like ‘bossware’. The rapid changes caused by the pandemic both reflected the direction in which work was already moving, while at the same time accelerated practices that were already becoming mainstream.

Having developed the connections between the pandemic and the broader context of technology and work, we ask our analysis says about human-centred computing’s (HCC) ‘future of work’ research agenda.¹ Observing that much of the work in

¹ We use the term ‘human-centred computing’ to encompass the broad range of communities in which this research is taking place (e.g. CHI, CSCW, CHIWORK).

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this agenda tends to focus on knowledge work and gig work, we advocate a renewed focus in HCC on 'traditional' forms of work and workplaces. There is a risk of our attention being drawn to kinds of work that are most salient to researchers in HCC; our research jobs may not be representative of many people's experiences of work. This, we will argue, has the potential to limit the size and scope of contributions that HCC research can make to bettering workplaces.

This is a position paper. It focuses on developing connections between remote work, workplace surveillance and the state of the art in HCC work research. We also analyse data from the UK's Office for National Statistics (ONS) to help to support the assertions that we make about the relationship between remote work and workplace surveillance. The purpose of writing a position paper is to encourage other researchers to think reflexively about the nature of their research and the people that it serves.

2. REMOTE WORK

We start by examining remote work. Remote work provides a useful lens for looking at the role of technology in modern work, because it is something that had been happening in organizations on a voluntary basis. When the pandemic arrived, suddenly organizations were effectively required by law to permit it. The ways in which organizations managed this process is revealing of the ways that organizations use digital technology for measuring and evaluating ways that their staff. We consider what remote work looked like before and during the pandemic, focusing on what changed and why we think it changed.

2.1. Pre-pandemic remote work

The 2020 coronavirus pandemic has caused major changes to remote work. To properly contextualize these changes, it is important to understand the state of remote work before the pandemic. To do this, we largely make use of state-collected data from a single country, the United Kingdom. The data reported in this paper are UK-specific, and the timeframes we discuss may also be specific to the schedule of UK lockdowns.

In the United Kingdom, the ONS has been collecting data on home working for a long time. These data are used by Felstead (2012) to make the case that remote working has grown more slowly than popular media might have reported since mainstream adoption of the internet (The Guardian, 2014). The most comprehensive pre-pandemic figures from the ONS² are from 2019. In these data, illustrated in Fig. 1, only 5% of UK workers reported working 'mainly' from home.

Prior to the pandemic, remote working was most prevalent amongst the most well-off workers in the most well-off parts of the UK: London and the South East. Managers were more likely than average to have mainly worked at home (10%), worked at home in the week before being surveyed (24%) or to have ever worked at home (45%). 'Elementary' occupations, which include porters, refuse collectors, cleaners and telephone sales workers, were less likely to have ever worked at home (4.2%) than a manager would have been to have worked mainly from home.

Prior to the pandemic, remote work was something that the majority of workers in all classes of occupation had not experienced. As the level of power, pay and prestige of roles increases, so

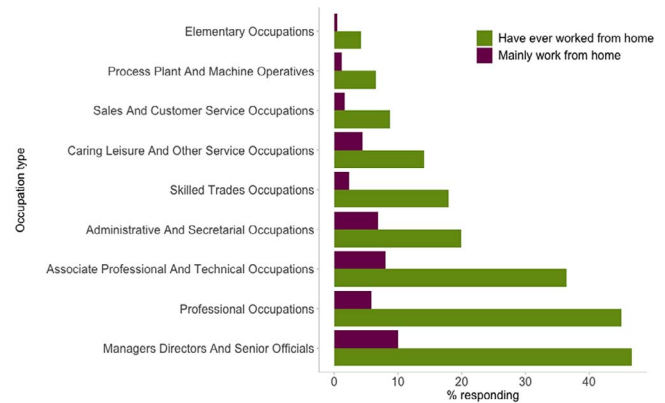


FIGURE 1. Pre-pandemic work from home propensity by different job classes. Data from the ONS.

workers were more likely to have any, regular or recent experience of working from home. A small percentage of workers were working 'mainly' at home, and those who were found at the higher end of the power, pay and prestige spectrum. So, as Falstead had noted, remote working was much less prevalent than its profile in published media might have suggested.

ONS data covers only the UK. Across Europe more broadly (the EU, UK and Norway), The European Working Conditions Survey (EWCS) 2015³ provides the most recent pre-pandemic data on remote work (or 'teleworking', as EWCS describes it). The 2020 EWCS was abandoned part-way through due to the effects of the coronavirus pandemic. The 2015 iteration of EWCS shows large variation in teleworking. Thirty-eight percent of Danes had some experience of remote work in 2015, compared to only 8% of Italians. Cyprus had the median value: 16%. The UK was quite close to the top of this distribution (27%, by the EWCS method). Ten years earlier, the 2005 iteration of the EWCS⁴ found the highest levels of remote work 'almost all the time' in the Czech Republic (9%), with no measurable remote working happening in Bulgaria or Malta. The average across the EU plus Norway was 1.7% of the workforce. Given this level of national variation even within Europe, detailed consideration of cross-cultural effects of the pandemic on remote work are beyond the scope of this paper, and we focus our analysis on the UK. However, these figures do help to make it clear that, prior to the pandemic, remote work was something of which very many fewer people had experience.

2.2. Remote work in the pandemic

In spring 2020, workers in the UK were told that 'everyone who can work from home must do so'.⁵ Many businesses were required to close their premises. In the UK, lockdown measures were announced by the Prime Minister on the 23 March 2020⁶; overnight, many people found themselves working at home for the first time, quickly having to develop new working strategies that were adapted to their technology and home environment (Rudnicka et al., 2020; Newbold et al., 2021; Cook, 2020b).

³ <https://www.eurofound.europa.eu/surveys/european-working-conditions-surveys/sixth-european-working-conditions-survey-2015>

⁴ <https://www.eurofound.europa.eu/publications/report/2010/telework-in-the-european-union>

⁵ <https://www.gov.uk/coronavirus>

⁶ <https://www.gov.uk/government/speeches/pm-address-to-the-nation-on-coronavirus-23-march-2020>

² <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/coronavirusandhomeworkingintheuklabourmarket/2019>

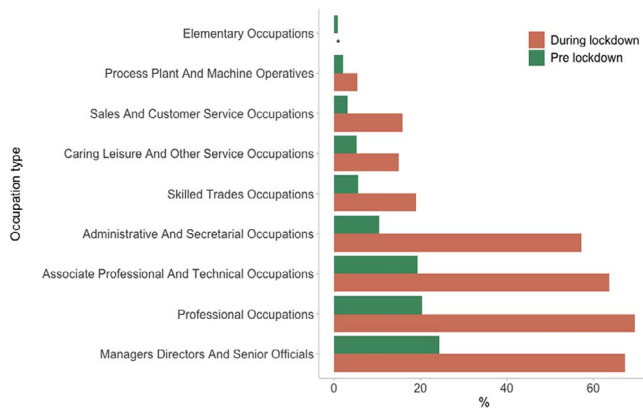


FIGURE 2. Proportion of people reporting working at home in the preceding week, pre-pandemic (December 2019) and during-pandemic (April 2020) by job class. Data from the ONS. ** There is no April 2020 data for 'Elementary Occupations'.

2.2.1. Prevalence of remote work during the initial phases of the pandemic

The effect of the pandemic on where people were working was marked. Again, we turn to data collected by the ONS⁷ to illustrate the impact. Figure 2 shows, at a variety of occupation levels, whether people reported working from home in the week before the survey was conducted. One sample is from a pre-pandemic week in December 2019 (green bars). The other is from a week in April 2020, at the height of the UK's lockdown (red bars). There are a few critical things to note here. The first is that, unlike the plot in Fig. 1, where the rates of working at home increase steadily with the power, prestige and pay of the occupation role (i.e. from 'Elementary Occupations' to 'Managers, Directors and Senior Officials'), this chart shows the pandemic having a bifurcating effect. 'Administrative and Secretarial Occupations' (which make up about 10% of the UK workforce⁸), professional occupations and management show a big swing to working online. 'Elementary Occupations' to 'Skilled Trades Occupations' show increases, but not of the same magnitude—probably because they necessitate physical presence for duties to be completed.

'Professional Occupations' show the highest rates of home working, at 69.6%, but home working is by no means ubiquitous; 43% of staff engaged in 'Administrative and Secretarial Occupations' were not working from home at this April 2020 peak. There are several groups in Fig. 2 showing only small increases in the rate of remote work. Only 2% of 'Process Plant And Machine Operatives' had worked from home before the pandemic. During the pandemic, this increased, but only to 5%. A rough interpolation of the data (see Table 1) shows that during the pandemic, 'Caring, Leisure And Other Service Occupations' working at home made up only 1.4% of the total workforce, but 'Caring, Leisure And Other Service Occupations' not working from home made up 7.8% of the total workforce.

Even at the most 'locked-down' point of the pandemic, significant numbers of people (most, even) were not working from home. When we are thinking about the future of work, it is critical that we, as researchers, are aware of the present of work too; not everyone has moved their work online during the pandemic. The

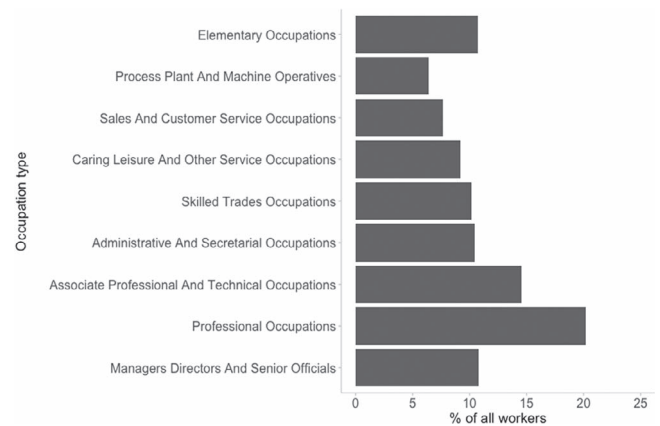


FIGURE 3. The proportion of the UK workforce in different occupation classes. ONS data, September 2018. Total size of workforce is 32.3 million people.

transitions that have occurred for people in professional occupations (like journalism and academia) have not been replicated to the same degree for everyone else. This has important implications for future work, which we discuss in detail later in this paper. People have remarked on the inequalities created by the pandemic (Partridge, 2020; Brussevich, 2020). We must remember that these inequalities in remote work, which map directly on to the power and control over different classes of occupation, existed before the pandemic. The pandemic has just exacerbated them.

One other significant aspect of these data is the size of the transitions to remote work for different job types. Prior to the pandemic, 19.9% of workers engaged in 'Administrative and Secretarial Occupations' had ever worked at home. At the peak of the lockdown in April 2020, 57.2% of the same cohort had worked from home in the past week. A total of 46.7% of 'Managers, Directors And Senior Officials' had ever worked at home before the pandemic. At the peak, 67.3% had in the preceding week. Figure 3 shows that these are all occupations comprising millions of UK workers. If we assume that the proportion of workers working from home during April 2020 represents the maximum number possible due to the nature of people's work and the ability of technology to facilitate remote work, then it is clear that many more staff doing 'Administrative and Secretarial Occupations' work are capable of working from home than have historically been permitted to do so; the proportional increase is much higher for these workers (from 10.5% to 57.2%) than for 'Managers and Senior Officials' (from 24.3% to 67.3%). There was, then, a greater gap between the proportion of people working from home on a regular basis in jobs with lower power, prestige and pay compared to those in positions with greater power, prestige and pay (Katsabian, 2020; Mahdawi, 2022). The pandemic has exposed the lower bound of the true proportion of workers who can work remotely. There may still be some number of workers beyond that bound who could work at home if their employer were to permit it and provide the necessary tools. This is why the figures from the ONS are a lower bound, rather than an upper one.

3. WORK MEASUREMENT

Why have workers in positions with less power, pay and prestige been able to work online during the pandemic, when previously they had perhaps not been permitted to do so? The data in Fig. 2 show a clear divide in the kinds of work that are and

⁷ <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/homeworking>

⁸ <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/employmentbyoccupationemp04>

TABLE 1. Combining the data from Figs. 2 and 3, let us provide an estimate for the total proportion of the working population working from home in April 2020 (41%). We can also break this down by major occupation groups. For example, people in 'Professional Occupations' made up 20% of the total workforce in 2018. When the pandemic arrived, 70% of workers in this occupational class worked from home. This meant that people in 'Professional Occupations' working from home made up 14% of the total workforce in April 2020. Note there is no April 2020 data for 'Elementary Occupations', but as this group includes bar staff, delivery operatives, groundworkers and kitchen assistants, it is reasonable to assume that only a very small proportion of them would have been able to work from home.

Occupation	% of total working population
Managers, Directors And Senior Officials	7.3
Professional Occupations	14.0
Associate Professional And Technical Occupations	9.2
Administrative And Secretarial Occupations	6.0
Skilled Trades Occupations	1.9
Caring, Leisure And Other Service Occupations	1.4
Sales And Customer Service Occupations	1.2
Process Plant And Machine Operatives	0.3
Elementary Occupations	—

are not amenable to remote work; if the roles of office workers in positions with less power, pay and prestige (i.e. 'Administrative and Secretarial Occupations') had been physically unable to move their work online, we would have seen the same pattern as we saw for, say, 'Skilled Trades Occupations' or 'Elementary Occupations'; very small increases in the rate of working from home. The fact that so many were able to move online but had previously not had the opportunity to do so suggests an organizational constraint, rather than a logistical or technological one. Likewise, people's preferences play a smaller role in whether they can work at home than organizational structures (Peters *et al.*, 2004).

Exhaustively account for the ways in which organizational structures might influence the permissibility of remote work for different classes of worker is beyond the scope of this paper. Rather, we focus on a particular organizational structure: the way that work is measured and evaluated. We focus on measurement and evaluation because the ability to collect, store and analyse large amounts of data about what workers are doing has grown substantially over the past few years, coming to define what 'productive' and 'unproductive' is in many workplaces (Calacci, 2022). In this section, we will explore organizations' dispositions to these kinds of technologies and their relationship to remote work. We also examine how organizations increased their use of these technologies when faced with workers who they could normally watch suddenly working from home.

3.1. Trust, control and remote-work

There are many interdependent factors that determine whether people work remotely (Errichiello and Pianese, 2016), but a particularly critical one is whether employers trust employees to be productive even when they cannot be closely monitored (Harrington and Ruppel, 1999). Pianese *et al.* (2022) reviewed 131 studies that investigated organizational control and remote work. Ultimately, remote work comes down to control, the 'set of mechanisms aimed at aligning employees' capabilities, activities and performances to organizational aspirations and objectives' (Pianese *et al.*, 2022, p.2). Pianese *et al.* found trust to be an important feature of control, even when other, more obviously coercive ways of enacting control exist. One of the challenges that workers have is to establish themselves as 'reputable employees' who can build 'cognitive trust' based on their competence rather than emotional connections. Especially in remote working contexts, establishing

this reputation and trust implies having forms of work measurement.

Smaller organizations tend to be more open to remote work (Mayo *et al.*, 2009), which makes sense given that the more frequent communications between managers and workers that occur in these settings increase interpersonal trust, and so managers' propensity to allow remote working (Staples, 2001). The question of how workers in larger organizations, where there are fewer opportunities for frequent communications with managers, go about demonstrating their productivity to a sceptical management class is an important one—and presumably one salient to remote-working workers, given that workdays expanded by an average of 48 minutes during the pandemic (DeFilippis *et al.*, 2020).

Trust works both ways, even if the nature of the relationship between worker and employer usually means employers generally get to assert their preferences. The way that these preferences are asserted significantly influence the extent to which workers trust their employers. When employers fail to communicate (or communicate ambiguously) about digital tracking tools, workers' trust in their employers is eroded (Stegman *et al.*, 2023). Staff trust of organizations also manifests in the acceptability of workplace tracking to workers. Constantinides and Quercia, 2022 evaluated 16 productivity tracking technologies, and found that the acceptability of these technologies varied depending on whether they were being used in a remote or on-site context. Charbonneau and Doberstein (2020) likewise found that although workers found all surveillance intrusive, they were actually less concerned about digital surveillance than they were about physical surveillance. Workers' trust is not, therefore, a simple function of the technology that is deployed, but is contingent on the context of its deployment.

3.2. Measuring the quality and quantity of work

Trust is an important component of remote work (and work more generally). It is developed mutually over time as a product of the way that work processes are designed (e.g. how they respect worker autonomy) and of workers' measurable contributions to those processes (e.g. what workers produce). Where employers are dissatisfied with their ability to observe contributions (for a wide definition of 'observe'), they will seek ways to increase their capacity and capability to surveil staff to restore 'trust'. This might include strictly enforcing presence, physically or digitally. It

might also involve using technology (both hardware and software) to track employees' activity. Moore and Robinson (2016) noted that at-work tracking is common across the world in industries ranging from construction (Choi et al., 2017) to law-enforcement (Eneman et al., 2018), and that tracking can increase workers' anxieties about their work. Generally, these technologies have been introduced in work roles where people experience lower power, pay and prestige and then are subject to a 'trickle up' process. The desire to deploy these kinds of tracking technology seems to be more common in remote work contexts where employees cannot be observed directly. In practice, these techniques are used to determine both whether someone is 'at work' (i.e. they are present, spending some quantity of time working) and also evaluate the way in which they are working (i.e. the 'quality' of their work').

The need for workers to demonstrate their productivity in remote work has been a salient challenge for new forms of gig-economy remote work. Alkhatib et al. (2017) considered crowdworking, a relatively new form of remote, distributed work, through the historical lens of piecework. Piecework, where people are paid per unit of their output, is a superficially simple solution to the trust-productivity question for employers. Rather than trust employees to work effectively for the time for which they are paid, piecework means workers are only paid for outputs and employers do not have to concern themselves with how much time or effort it takes for the worker to produce work outputs of acceptable quality. The gig economy, whether workers are delivering food, parcels, cleaning services or labelling images for machine learning systems, operates on this model of transferring risk involved in maintaining productivity onto workers by only paying workers for the number of 'gigs' completed rather than an hourly rate.

Alkhatib et al. (2017) note that unlike historical piecework, where the monitoring of the working processes was uncommon (the focus being on whether the output was of sufficient quality), more modern forms of gig-economy piecework have incorporated tracking technologies that monitor the process of how work is completed (see, e.g. Liang et al., 2019). The nature of tracking in crowdwork helps crystallize aspects of contemporary digital tracking. For a lot of work, measuring 'output' is challenging in the way that, for instance, counting the number of hats of acceptable quality someone produced in a day was not. For some kinds of task, the way in which a task is conducted is also important to the acceptability of an output too; outputs are not fungible (i.e. interchangeable) in the way that items from a production line might be. Thus, tracking becomes desirable to employers to observe both quantity of work that is happening (i.e. whether people are attending to their work), but also to understand how work is happening so that quality can be judged. On crowdworking platforms, for example, concerns about data quality mean that attention checks (Abbey and Meloy, 2017) are frequently used. The purpose of the checks is to detect workers who are not completing tasks in a desirable way (Gould et al., 2018). This is partly because of the nature of the 'output' that is sometimes required; the ways in which data for empirical studies is created is critical to whether the output is acceptable, for instance. Tracking the way that work is conducted assists the 'algorithmic management' of workers (Wood et al., 2018) too: the way that people complete piecework tasks can be used to further refine the models of work that underpin work platforms like food delivery. Finally, the tracking of processes also reflects the fact that work is taking place on and through digital technology that makes it easier to enable tracking of low-level work with little cost to the employer at the point of

collection (see Rzeszotarski and Kittur, 2011, Gould et al., 2016, for examples of how telemetry can be collected in browser-based work).

Although the ability to surveil workers has a variety of potentially negative effects on employees, it is important to say that the technology used to surveil also has the potential to be used by workers for their own ends, too. Englert et al. (2020) explain that the increasing role of technology in mediating our interactions does not only increase the power of employers (even if it skews in that direction)—technology might increase surveillance but can also be appropriated by (or even actively marketed to⁹) workers to understand their own behaviour. The same underlying telemetry-based technologies can be appropriated for use in different ways (although it is important to think about ultimately who can control and exploit data at scale). For people interested in the quantified self-movement—where people seek to log and measure particular aspects of their life—low-level tracking gives the desired insight into their behaviour (Elsden et al., 2016; Epstein et al., 2015). Some people are keen to do this in order to understand the nature of their work (Moore et al., 2018). It might even be used by workers in a collective fashion to make claims on productivity, measuring the things that workers, collectively, think best reflect their output (Cecchinato et al., 2021).

3.2.1. 'Bossware' and the pandemic

With the arrival of the pandemic, employers were faced with many employees who did not have logistical or technological impediments to working remotely, but who in the past had not been trusted to work remotely. Employers did not have the option of bridging the trust gap by following the gig economy model of turning their regular workforce into pieceworkers. Instead, many employers turned to 'bossware' to bridge the trust gap as their workforce started to work remotely (Gullo, 2020; Aloisi and De Stefano, 2021; Manokha, 2020). This mirrored a wider increase in surveillance across society as a consequence of the pandemic (Tréguer, 2021; Westerlund et al., 2021).

Bossware is a kind of surveillance software that is used by employers to capture workers' activity—whether they are working from home or at the office. Bossware might involve collecting telemetry about the kinds of applications staff use, or it might involve particularly invasive keylogging, screen capture and recordings from cameras. This kind of monitoring, as we have discussed, has been standard in piecework-based gig-economy work for some time. Upwork, an online platform for contract software development, has given those paying for work the option to watch workers in this way for more than a decade. The idea is that employers put these tools onto staff devices and, if they feel a particular member of staff is not being sufficiently productive, then they can watch, in real time, what a worker is doing (Otto, 2018). In this way, employers do not need to trust their workers to produce; they can instead attempt to enforce productivity through remote digital surveillance of their workforce. The switch to remote work during the pandemic enabled technology companies to play an important role in increasing the ability of employers to surveil their employees, as the furore over Microsoft's productivity tracking tools demonstrates (Hern, 2020). The tool, a part of Microsoft's widely used Office 365 package, allowed—by default—managers to look at who participated in chats and how many emails different workers were sending.

As well as engendering broad questions about the ethics and employee acceptability of deploying these kinds of tools, the use

⁹ For example, <https://www.rescuetime.com/>

of bossware merits critical consideration on its own terms, too. Scott's influential work, 'Seeing Like a State' (Scott, 1999), focused on agricultural work, but its conclusions are highly relevant to the telemetry-based surveillance of remote workers. Scott's thesis was that actors (such as states, organizations or employers) were limited in what they could measure by the processes they had for collecting and evaluating data. In other words, what can be modelled becomes the reality, and it is this newly constructed reality that becomes the basis for planning and evaluation. Ultimately, reality is coerced to fit what can be measured. Scott writes that 'this is not merely a question of inventing measures that accurately reflect the facts on the ground and that can be conveyed to administrators. It is, above all, a question of changing the environment so that it is more standardized to begin with' (Scott, 1999, p. 339). What kinds of questions about people's work practices do these tools let employers ask, and is there a risk that what can be measured ultimately replaces more nuanced and sophisticated understandings of what a 'productive' worker looks like in a given context? As Alkhatib et al. note, piecework was ultimately replaced in many areas of work because it was not able to capture complex high-value outputs that advanced economies produce (Alkhatib et al., 2017, p. 4601). Thinking about office workers working remotely makes this even more explicit; trying to value the output of individual office workers is difficult in a way that counting the number of pins or hats someone has produced is not. And these workers moving online makes it even more difficult to perform such 'valuations'.

Bossware is naturally constrained in what it can measure by the technology platforms on which it is built. Not all that comprises work can be captured through clicks, keypresses and window switches, but these are the kinds of measures that bossware tools often use. There is a risk that if, as has been predicted (Clancy, 2020), remote work becomes a more permanent feature of many people's work, the kinds of aggregable telemetry that it is possible to collect about work (including presenteeism-inducing measures like the time someone spends in front of their webcam) will ultimately constitute how employers assess productivity and performance. What is important (quality and quantity of output) will be reduced to what can be measured (process), as Scott suggested. The problem with this is that what can be measured through telemetry may not fit actual organizational objectives. The risk is that workers 'satisfice'—optimizing their efforts to appear most productive by the telemetric measures, rather than adhering to critical organizational goals. In other words, this can create perverse incentives for employees. Satisfying to meet perverse incentives is not something new within online contexts, but in remote work settings the problem is particularly acute because unlike satisficing in traditional workplaces (Vezyridis and Timmons, 2014; e.g. in healthcare), in remote workplaces, the metrics might be the totality of a manager's view of work. At least in traditional workplaces, managers have other, more informal (e.g. coffee hours, away days) and more nuanced (e.g. hard to measure aspects of people's contributions to productivity like mentoring junior staff) channels for understanding what work is happening and how that work is being done.

Relying on telemetry from digital devices to assess productivity is also a problem because most employers do not have the kind of expertise that affords a critical understanding of where data comes from and the kinds of conclusions that can be drawn from it. Sometimes, the work of understanding gets subcontracted to 'AI' systems that produce more digestible classifications, such as the productivity metric in Rescuetime (Collins et al., 2014) or the

Microsoft tool we've already described, but these are 'trained', of course, on the same limited metrics. Many bossware tools, recognizing that only so much can be learnt from behavioural telemetry, have the option to capture live feeds of workers' screens and webcams. The lack of trust that the pandemic has exposed is crystallized in some employers' desire to capture everything, even if there is no obviously efficient way to make sense of it. Every keystroke, every webpage visited, pop-up instructions to workers who've gone to use the toilet to resume work (Christian, 2020; Allyn, 2020). Is a manager watching workers working to see if they are being productive a net improvement to an organization's productivity? The deployment of bossware during the pandemic suggests at least an organizational belief in the efficacy of these kinds of intrusive tracking technologies. But such scenarios have the feeling of the Borges fable 'On Exactitude in Science'. In the story, a fictional empire's refinement of cartography and desire for exactitude means that satisfaction is only achieved once a 1:1 scale map of the empire is produced. Some employers have seen bossware as a way of creating a 1:1 representation of people's work while they are working remotely, but the trust deficit that is the impetus for this kind of collection cannot be satisfied with more data—and the data collected in this way is so voluminous so as to be anyway inscrutable. This kind of fidelity for fidelity's sake makes little sense organizationally or economically.

4. THE FUTURE OF 'FUTURE OF WORK' RESEARCH

We have seen that there is significant variation in the classes of worker that are able to work remotely. We have also seen how this connects with the variation in the ways that work is (or could be) measured and evaluated using technology across different classes of work. The dematerialization of work and its measurement is one of the major changes that technology is enabling. Characterizing the variation in how this is happening across work classes and understanding its differential effects across the workforce is, to us, a critical challenge for those seeking to understand how technology might continue to develop in the modern workplace, and what its attendant effects on workers might be. We wonder whether human-centred computing research on the changing nature of work is sufficiently engaged in this variation, and in this section we explore what we see as some of the limitations to our collective approaches to understanding variability in workplaces and the digital measurement and evaluation of workplace activity. Given the centrality of digital measurement to contemporary work, it seems necessary for our research community to address some of these limitations.

The pandemic has accelerated thinking about the future of work, with many articles in popular media wondering whether the changes to work wrung by the pandemic are here to stay (Clancy, 2020; Timpson, 2020; O'Connor, 2020). As researchers, it is easy to get swept up in this idea. After all, researchers, like journalists, are members of a professional class of workers, and no class, in the UK at least, has seen a bigger transition to remote work. The kinds of workers who are most likely to have switched to working at home (i.e. the 'Professional Occupations' of Fig. 2) are the kinds of people who are most likely to be trying to understand and develop the future of work: journalists, academics, knowledge workers in technology companies.

The ONS statistics for the UK labour force that we have already described are clear, though. Even in classes of occupation where big movements toward remote work occurred, the move was nowhere near ubiquitous. And for many other classes of work, the

classes of which journalists, academics and technology company employees are not members, the move toward remote work was very much smaller; no more than one-in-five workers in more hands-on occupations moved to remote work at the height of the first wave of the pandemic. This tells us something about the nature of most people's work. But it is important to remember the pandemic context in which these changes have been made mean we need to treat phenomena arising in these terms carefully. It is not simply the case that the pandemic has sped up a transition that people have been saying has been inevitable for a long time; working in a pandemic is still working in a pandemic, with all the disruptions to normal home and work life that it entails. The commensurability of what we learn during the pandemic with 'normal' times is therefore uncertain.

'The Future of Work' is an idea that HCC researchers were increasingly focusing on before the coronavirus pandemic (e.g. Lindley et al., 2019). The intersection of work and technology covers a huge variety of questions about the role of AI (Thakkar et al., 2020) or labour (Fox et al., 2020). The coronavirus pandemic has significantly accelerated interest, especially in the kinds of futures implied by changes to work during the pandemic. A Microsoft Symposium in the summer of 2020 produced 67 publications¹⁰ on the topic of 'the new future of work'. But the vast majority of these papers (including one by the authors of this paper) focused on new forms of distributed gig economy work, or on remote knowledge work, over kinds of work that might be more representative.

When we consider how we think of the future of work as researchers, we think it is vital to avoid falling into two 'traps':

- Thinking that work for most people looks like it does for us and the people we work with.
- Thinking that the trajectory for all work is the trajectory of new forms of work.

As researchers, it is important that we are understanding the role of technology across a variety of working contexts. There is a risk that too much focus on particular classes of work mean that when we talk about 'the future of work', all we are really talking about are a narrow set of futures that relate to particular classes of work that are particularly well understood by (or are familiar to) researchers. As researchers, the visibility of these changes to our work, and the work of the people we are normally working with, lead us to believe that work has changed radically for most people and that the future of work has arrived. It is important to resist this conclusion, because it means HCC risks overlooking the ways that technology is used outside of knowledge work. This is historically unsurprising, given the distribution of digital technology, but today strange because technology is everywhere. Outside the highest-skill knowledge work, there are still huge numbers of HCC problems to be solved for tasks as mundane as the transcription of expense claims (Borghouts et al., 2020). Addressing the problems faced by these workers, including developing remote work for people in jobs with low organizational trust (Tan and Cox, 2019), has the potential to improve work for a large proportion of the working population.

Another focus of HCC work and technology research has been new forms of gig-economy work, such as crowdworking. These ways of working are naturally of interest to HCC researchers (Kittur et al., 2013), being, as they are, wholly technology mediated (Ross et al., 2010). Their utility as a source of data in empirical studies has provided another reason for them to be interesting (Kittur et al., 2008; Germine et al., 2012). The often exploitative nature

of these platforms means there are many questions about how technology can help workers cope with the challenges presented by their working conditions (Irani and Silberman, 2013; Salehi et al., 2015).

The risk is that the radically new forms of work that have emerged over the past 15 years, of which crowdworking is one kind, become a schema for what *the future of all work looks like*. If these new forms of work are presaging the future of all work, then there is certainly a lot to worry about. The focus of contemporary HCC research on one of two futures—a dystopian one where people become a pieceworker in a modern workhouse (Alkhatib et al., 2017), or a future where remote working provides positive flexibility for highly skilled knowledge workers (Cook, 2020a)—means that it's easy to miss out on the role that technology is playing in work that is more representative of the experiences of most workers. There is a risk that research instead becomes overly focused on work contexts that are broadly unrepresentative of what work looks like for most people. Only 30% of the UK workforce are classed as being 'Managers, Directors and Senior Officials' or in 'Professional Occupations', and 'Professional Occupations' includes nurses and teachers whose interactions with technology generally do not look like those of office-based knowledge workers.

The experiences of 'Administrative and Secretarial Occupations' staff, things like typing data into web forms, might feel like something that is the 'past' of work. But this is what work looks like for millions of people (Fig. 3), and technology has the potential to make work a little better in these contexts (Borghouts et al., 2020). One perspective is that the future of work for jobs like this is that they will be automated away, but that is unlikely in the near term. It's more likely that semi-autonomous intelligent systems will be helping people do these kinds of 'traditional' jobs more effectively.

To avoid falling into the traps we have described, researchers (including the authors of this article) need to be reflexive, thinking about their own work and being creative about the possibilities for investigations across a variety of different but contemporaneous futures. As researchers, our personal circumstances and experiences can influence the way that we do research, but also the kinds of questions that we ask and the things that we ask them about (Bell and Willmott, 2020; Roulston et al., 2008; Gould, 2022). An 'extreme' way of getting a feeling for other kinds of work might be to conduct an autoethnography [Toombs et al., 2018] and get hands-on experience of a role. Clearly, this is not an option for everyone, though, and there are methodological and ethical challenges that come with deep, activist, engagement in research (Bates et al., 2020).

Another thing we can do is to remember the value of incremental, parametric work and marginal gains. As we've seen earlier in the paper, more than 10% of the UK workforce (some 3.4 million workers) are engaged in 'Administrative and Secretarial Occupations'. Small advances in understanding, or marginal improvements to productivity, can be valuable if they apply to aspects of work that are common to lots of different kinds of work. We need ways of valuing research that makes small additions to knowledge or practice in mundane contexts.

When we are investigating the future of work, we need to be considering what the present looks like for a representative sample of people and so what shape the future might take. One way to elicit creativity when thinking about work for different demographics is to use design fiction probes (Noortman et al., 2019). These are a kind of research device that allow researchers and research participants to think creatively about futures by

¹⁰ <https://www.microsoft.com/en-us/research/event/new-future-of-work/>

thinking about possibilities in fictional worlds. They have already been used to expand people's thinking about the future of work (Fuchsberger et al., 2017; Forlano and Mathew, 2014). Balancing this, though, is a need to interpret design fictions about the future of work with a degree of skepticism. People's expectations and beliefs about what work could look like can be substantially different to the reality. For instance, digital nomads, people who switched from more 'normal' working practices to an itinerant one travelling the world while working, have found significant differences between what they thought being a digital nomad would be like and the reality that they encounter (Cook, 2020a).

5. CONCLUSION

The pandemic has demonstrated that remote work has been withheld from some classes of worker, not for logistical or technological reasons, but because of organizational ones. Workers in roles with lower power, pay and prestige previously had little experience of remote work, but were able to move to remote working en masse. However, the trust deficit between employers and these workers that precluded remote work in the past did not disappear with the pandemic. Instead, technology, especially telemetry-based tracking through 'bossware', was used by employers to try and surveil the productivity of workers. This kind of tracking is increasingly prevalent across workplaces, but is particularly advanced in new forms of remote distributed work, like crowd-working. The situation in these kinds of working contexts suggests that increasing surveillance of workers does not bridge the trust gap between workers and their managers. We've argued that for some kinds of work the pandemic has caused qualitative changes to how work happens, but for a significant proportion of the working-age population (in the UK, at least), there was no mass migration to remote work during the pandemic. Where workers were in occupations that were amenable to remote work, we saw that the broader context, the zeitgeist of work, meant that existing trends in the workplaces (e.g. invasive surveillance of work and workers) were magnified. Workplaces are heterogenous in terms of organizational processes and the ways that digital technology is used to measure and evaluate work. The pandemic has reinforced the need for human-centred computing researchers to understand the role of technology across a broader variety of workplaces, and not just in novel working environments or working environments that closely resemble those of researchers. Understanding this variety would, we think, mean that research will be better able to anticipate future changes to work and develop ways of ensuring that workers have as much agency as possible, that the ways that work is measured is as legible as possible, and that workers have the maximum possible capacity to negotiate over the way that data about their work is collected (Mortier et al., 2015).

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Author Contribution

Gould wrote the first draft. Rudnicka, Cook, Newbold, Cecchinato and Cox have contributed to the redrafting of the paper. All authors participated in the development of the ideas presented in this paper.

Data Availability Statement

The data used in this manuscript were produced by third-parties. We have linked to data sources.

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