



Productivity of Working at Home and Time Allocation Between Paid Work, Unpaid Work and Leisure Activities During a Pandemic

Samare P. I. Huls¹ · Ayesha Sajjad¹ · Tim A. Kanters^{1,2} · Leona Hakkaart-van Roijen¹ · Werner B. F. Brouwer¹ · Job van Exel¹

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Abstract

Background and Objective The COVID-19 pandemic and the measures taken by governments to contain it have affected many aspects of the daily lives of citizens. This study aimed to describe changes in the productivity of paid work and time allocation to paid and unpaid work and leisure resulting from working at home during the pandemic.

Methods A sample of 851 people from the Netherlands who had paid work (≥ 24 h/week) and worked at least 4 hours per week extra at home because of lockdown measures completed a questionnaire during the first COVID-19 lockdown (April 2020). Respondents reported time spent on paid and unpaid work and leisure before and during the lockdown. Productivity was measured in terms of quantity and quality of paid work.

Results On average, respondents spent less time (14%) on paid work and productivity decreased 5.5%. Changes in productivity were associated with the age of children, net income and having a separate home office. Respondents spent more time on unpaid work (27%) and leisure (11%). Women spent more time on unpaid work in absolute but not in relative terms. People with a partner and with children spent more time on unpaid work and less time on leisure.

Conclusions Productivity of paid work decreased, and people reallocated time between paid and unpaid work and leisure during the first COVID-19 lockdown. Changes in time allocation and productivity differed across subgroups. If working at home becomes more common, future research should focus on the long-term impact on productivity and mental and physical health.

Key Points

Many employees worked less during the COVID-19 lockdown and were less productive.

The decrease in productivity was largest for people with young children, a low income and who did not have a separate office at home.

Women spent more extra time on unpaid work than men.

1 Introduction

In many countries, the COVID-19 pandemic and the measures taken by governments to contain it in order to protect the health of the population also affected many other aspects of the daily lives of citizens. In the Netherlands, like in many other countries, working at home was strongly advised as one of the ways to reduce infection rates. Such policies, while perhaps contributing to reduced infection rates, also have socioeconomic consequences [1], including changes in the productivity of employees. Understanding the consequences of measures like working at home may help to make a good assessment of their costs and consequences as well as to formulate ways of reducing potential negative (side)effects. Moreover, this information is valuable because our methods of working might change permanently, with working at home remaining more common also after the pandemic [2–4]. This paper therefore describes a study set out to estimate changes in the productivity of paid work and time allocation to paid and unpaid work and leisure activities resulting from working at home during the COVID-19 pandemic.

✉ Samare P. I. Huls
huls@eshpm.eur.nl

¹ Erasmus School of Health Policy and Management, Erasmus University Rotterdam, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands

² Institute for Medical Technology Assessment (iMTA), Rotterdam, The Netherlands

Having to work at home may affect productivity in different ways. Some types of work simply cannot be performed at home because of the required equipment (e.g. heavy machinery) or the nature of the work (e.g. waiter or actor) [3]. Not being able to do your work because you are not able to go to your workplace then potentially implies a complete loss of your productivity (in paid work). For other types of work, it may be feasible to perform at least a part or the normal activities at home [3]. However, even if all activities could be performed at home, this does not necessarily imply that productivity would remain the same when actually having to do so. For instance, the working environment and facilities may be less optimal at home than at the workplace [5]; distractions from work by other household members or the lack of an adequate place to work (e.g. desk, chair, own room) at home can reduce productivity. However, if employees and employers invest in physical and human capital and in innovations that support working at home, productivity may actually increase [2], also because of reduced travel time.

Productivity not only concerns paid work, but also unpaid work. Even though it is less often considered in economic evaluations [6], unpaid work should also be incorporated when analysing the full societal impact of public health issues [7]. Having to work at home may have positive and negative consequences for unpaid work, and the distribution of unpaid work within a household may change [8]. For instance, people who are not able to perform all of their normal paid work activities may spend (a part of) the freed time on unpaid activities (e.g. home improvements). In contrast, people with children may have to increase their time on unpaid activities (e.g. home schooling), potentially at the expense of time spent on paid work.

The changes in time spent on paid and unpaid work activities as a result of the lockdown measures may also affect the time available for leisure. Changes in leisure time are important in relation to the evaluation and sustainability of the overall changes in time allocation over prolonged periods of time [9]. Indeed, spending more time on paid *and* unpaid work at the expense of leisure in order to avoid losses in productive activities or address higher demands of paid or unpaid work may be perceived as negative and only bearable for a certain period but not a viable solution over longer periods of time. However, an increase in leisure time can also positively affect productivity [10].

The changes in allocation of time to paid work, unpaid work and leisure may of course vary across subgroups of the population, according to the types of work and other circumstances. During the pandemic, the amount of people working at home was found to differ per industry [11, 12], with higher percentages of people with high incomes [2, 11, 12] and high education [12] working at home. Gender, marital status and having children did not seem to impact the ability to work at home [11]. However, women did experience more

changes in paid working hours and carried a heavier load in childcare and household work than men [8, 13, 14]. Women with children experienced more psychological distress than women without children [8], and a larger decline in time spent on leisure activities than men with children [14]. The age of children was found to matter in the work-life balance [15], but no gender differences were found [14].

This paper presents the results of a study conducted to investigate changes in productivity in relation to paid work, in terms of quantity and quality of work, and time allocation to paid and unpaid work as well as leisure activities as a result of working at home during the COVID-19 pandemic. Furthermore, it assesses whether these changes vary between subgroups of the population. Data were collected at the time of the first wave of COVID-19 infections in the Netherlands, when the government had introduced lockdown measures that urged people to work at home and schools and day care facilities for children were closed. This information is relevant in both looking back on the full societal impact of coronavirus and measures to counter it, as well as in looking forward to potential future lockdowns and other measures encouraging or enforcing working from home.

2 Methods

2.1 Survey Administration

A cross-sectional survey was administered online to a sample of adult working people in the Netherlands recruited by the survey sampling company CG Research. People were eligible if they (1) had paid work for at least 24 hours per week before the pandemic, (2) worked at home at least 4 hours per week extra as compared with before the pandemic, and (3) were between 18 and 67 years old. The survey was administered between 22 April and 2 May, 2020. The sample was selected to be representative of the population according to gender, age (18–27, 28–37, 38–47, 48–57, 58–67 years) and composition of the household (partner: yes/no; children: yes/no). All respondents consented to the information they provided being used for research purposes and they received a reward equal to a financial compensation of €1.50 upon completion of the survey. The study was approved by the Ethical Review Committee of Erasmus School of Health Policy & Management (IRB 20-12).

Figure 1 shows the number of reported infections [16] and the stringency index of pandemic policies [17] at the time of data collection in the Netherlands. As of 12 March, people were advised to work at home and as of 15 March, all schools, day care for children, restaurants and sports clubs were closed. With the partial lockdown that started on 23 March, group sizes became restricted to two and people working in contact-based professions such as hairdressers and driving instructors were no longer allowed.

2.2 Data

The first part of the survey consisted of questions about respondents; personal characteristics and characteristics relating to the work and home situation before the COVID-19 lockdown measures were introduced (t_0). Then, respondents were asked about their current situation (t_1), and their productivity. Questions about time allocation to unpaid work and leisure before and during the lockdown measures followed. A more detailed description of the variables used in this study (paid work, productivity, unpaid work, leisure activities and personal characteristics) follows below.

Time spent on paid work was measured in two ways, namely, where (t_0) refers to weekly hours spent before the COVID-19 lockdown measures were introduced and (t_1) refers to time spent during the lockdown. Differences between time spent before and during the lockdown are defined as Δt . Both Actual hours _{t} and Contract hours _{t} were respondent reported, with the first referring to the actual number of hours spent on work (i.e. including potential overtime and undertime), and the latter strictly referring to the number of hours in a respondent's contract. Following Brouwer et al. [18], productivity is driven by three concepts, namely work hours, average quantity of completed work and average quality of completed work in those work hours. As such, changes in productivity are measured using the following composite measure:

$$\text{Productivity}_{\Delta t} = \frac{\text{Contract hours}_{t_1}}{\text{Contract hours}_{t_0}} \times \text{quantity of work}_{\Delta t} \times \text{quality of work}_{\Delta t} \times 100\%,$$

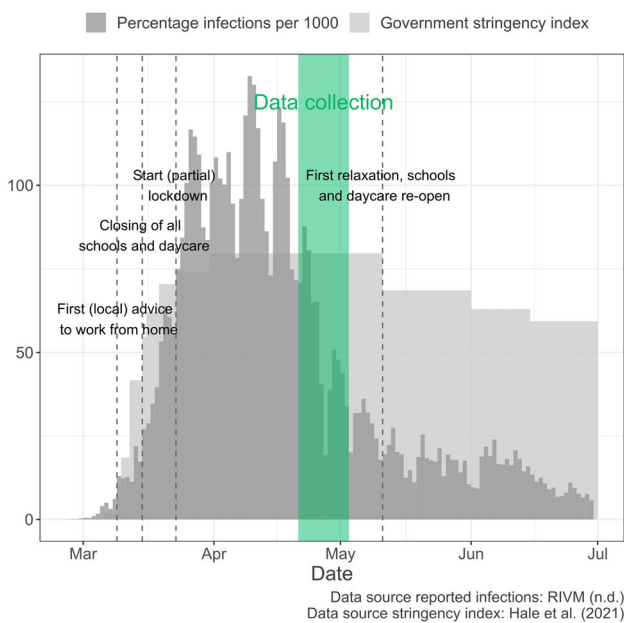


Fig. 1 Dutch situation around the time of data collection, spring 2020 [16, 17]

where values between 0% and 100% indicate a loss of productivity during the COVID-19 lockdown as compared to before, and those above 100% indicate a gain in productivity. Quantity of work _{Δt} , as derived from the iMTA Productivity Cost Questionnaire [19] and Quality of work _{Δt} , measured in a similar manner, namely numerically (grade between 0 and 10) following a three-category (higher/equal/lower)question¹. As the meaning of the grade between 0 and 10 differed depending on whether quality/quantity was higher, equal or lower, values were rescaled to range between zero and two. A value between zero and one indicated a decrease, a value of one indicated equality and a value between one and two indicated an increase.

Time spent on unpaid work was measured in terms of eight types of activities, namely: household work, preparing meals, childcare, supporting children in education, informal care for a household member, informal care for others, jobs around the house/garden and voluntary work. This list of activities was based on the examples given in the iMTA Productivity Cost Questionnaire [19]. Based on discussions within the research group, some activities were rephrased in a manner such that it was possible to spend time on them regardless of the lockdown measures (e.g. contact with friends/family rather than meeting friends/family). Respondents were asked how many hours they spent on these activities before the lockdown by filling in "... hours per week" for each activity. Thereafter, they were asked how

many hours more/less they spent on each of these activities weekly, again by filling in "... hours more per week" or "... hours less per week". For time spent on leisure activities, eight types of activities were distinguished: relaxation with household members, relaxation alone, contact with family, contact with friends, moderate exercise, intensive exercise, watching TV (including video streaming), and social media and the Internet. This list of activities was constructed based on discussions within the research group, and again such

¹ Phrasing of follow-up question if lower quantity reported: "You indicated that you were able to do less than usual during the hours you worked in the past week. Select the number below that best matches how much work you were able to do during these hours on average. The 10 means that during these hours you could do as much as you normally would. The 0 means that you could not do anything during these hours."

Phrasing of follow-up question if higher quality reported: "You indicated that during the hours you worked in the past week, the quality of your work was higher than usual. Select the number below that best matches the average quality of your work during these hours. A 10 means that the quality of your work during these hours was twice as high as normal. A 0 means that the quality of your work during these hours was the same as usual."

that it captured activities that were possible regardless of lockdown measures.

For subgroup analyses, information was also collected on age (18–34/35–49/50–67 years), gender (male/female), having a partner (yes/no), having children living at home (yes/no), children in the age categories 0–3, 4–12 or 13–17 years (yes/no), which corresponds to pre-school, primary school and secondary school ages, education level (low/middle/high), net individual income before lockdown (< €2000 /€2000–€2999/€3000–€3999/€4000–€4999/≥ €5000/Don't know/Rather not say) and whether respondents could avail of a separate office at home (Yes, I can use a separate office all day long/Yes, I can use a separate office for part of the day/No). In addition, respondents were asked whether they had a government-defined crucial job (i.e. working in healthcare, transport, education or other vital profession), meaning that they were allowed to go to their workplace and their children were allowed to go to school or day care.

2.3 Analyses

To get a broad understanding of the data, time allocation to paid work (contract hours and actual hours), unpaid work and leisure activities were described for the general sample as well as per subgroup. We performed paired t-tests to compare changes in time spent before and during the lockdown. In addition, Pearson's correlations between these four categories of time allocations were computed. Productivity in paid work was also studied by performing a linear regression to support the descriptive results regarding associations with age, gender, having a partner, the age of children living at home, education level, net income and whether respondents had a separate office. To optimise model specification, variables of which the variance inflation factors were higher than 5 [20] were deleted. If this did not improve the R-squared, the variables were retained. Unpaid work and leisure activities were further examined descriptively by inspecting differences between subgroups defined by gender, having a partner and having children in the different age categories. Please note that given the nature of the data, some transformations were performed before the data analysis. More information about these can be found in Table 6 of the "Appendix".

3 Results

In total, 851 respondents met the inclusion criteria, provided informed consent and completed the survey. Sample characteristics can be found in the leftmost columns of Table 1. Thirty percent of respondents were aged between 18 and 34 years, 33.5% were aged between 35 and 49 years, and the remaining 36.5% were aged between 50 and 67 years. Slightly more than half of the respondents were male

(53.0%), 70.5% of respondents had a partner and 35.5% had children under the age of 18 years living at home. Most respondents were highly educated (61.3%), were willing to disclose their net monthly household income (85.5%) and 28.3% had a government-defined crucial job.

3.1 Time Allocation per Week

Table 1 gives an overview of respondents' time allocation per week. As the first row of the table shows, the mean number of contract hours of paid work was 35.2 per week before the COVID-19 lockdown. This number decreased by 2.5 h (7%) during the lockdown. The largest relative losses in contract hours occurred in respondents with a low income, low education and in people with young children. On average, these respondents lost at least 10% of their paid working hours. The actual mean number of hours spent on paid work was 34.8 per week before the lockdown. During the lockdown, this number decreased by 4.8 h (14%), which is almost twice as large as the decline in contract hours. Young respondents, respondents with young children, a low education or without a separate office experienced the largest relative decline in actual hours spent on paid work. All changes in time spent before and during the lockdown were statistically significant ($p < 0.001$), besides changes in volunteer work ($p = 0.55$). Fig. 2 shows more detailed information about the distribution of (changes in) the time variables. The top left panel, for example, shows that respondents generally had more contract hours of paid work before the lockdown (green line) than during (yellow). The orange line (differences) and its peak around zero show that for most people, there were little changes in contract hours. The slight skew to the right confirms what is observed in the green and yellow lines: if there are changes, most people had less contract hours of paid work. The other figures can be interpreted in a similar manner.

The amount of time spent on unpaid work on average increased by 27% during the lockdown, with respondents aged between 18 and 34 years, with a higher income or a separate office for part of the day experiencing the largest relative increase in time spent on unpaid work. Time allocated to leisure activities on average increased by 11%. This relative increase was highest for people with a separate office part of the day, followed by respondents with an income below €2000. The total amount of time spent on paid work, unpaid work and leisure activities together was 99.1 h per week before the pandemic and increased by 5 h (5%) during the lockdown. The increase in total time spent on these three categories was largest for respondents with children in the two youngest age categories or a separate office part of the day.

Furthermore, we found that changes in time spent on paid work (both contract and actual hours) were similar for men and women. In absolute terms, women spent more extra time

Table 1 Sample characteristics and time allocation to paid work, unpaid work and leisure (mean hours per week)

Variable	N (%)	Paid work: contract		Paid work: actual		Unpaid work		Leisure		Total hours: actual							
		t_0 (SD)	Δt (SD) (%)	t_0 (SD)	Δt (SD) (%)	t_0 (SD)	Δt (SD) (%)	t_0 (SD)	Δt (SD) (%)	t_0 (SD)	Δt (SD) (%)						
N	851 (100)	35.2 (5.4)	- 2.5 (7.6)	- 7	34.8 (13)	- 4.8 (14.9)	- 14	21.1 (17.8)	5.7 (10.1)	27	43.3 (19.4)	4.9 (12.8)	11	99.1 (20.8)	5.0 (19.5)	5	
Age (years)																	
18–34	255 (30.0)	35.3 (5.3)	- 2.9 (7.6)	- 8	34.2 (13.2)	- 6.9 (16.3)	- 20	19.9 (18.3)	6.2 (10.0)	31	45.9 (21.3)	5.3 (12.7)	12	99.7 (20.8)	3.3 (21.0)	3	
35–49	285 (33.5)	34.9 (5.5)	- 2.0 (7.3)	- 6	33.8 (13.3)	- 3.0 (14.0)	- 9	26.5 (20.4)	6.9 (11.5)	26	39.1 (17.6)	3.7 (12.3)	10	99.4 (20.3)	7.1 (17.9)	7	
50–67	311 (36.5)	35.5 (5.4)	- 2.6 (7.9)	- 7	36.3 (12.5)	- 4.8 (14.3)	- 13	17.2 (13.1)	4.1 (8.4)	24	45.1 (18.7)	5.7 (13.3)	13	98.4 (21.3)	4.5 (19.5)	5	
Gender																	
Male	451 (53.0)	37.3 (4.2)	- 2.5 (7.9)	- 7	38.1 (12.5)	- 4.8 (14.3)	- 13	17.7 (13.8)	4.7 (7.7)	26	42.3 (18.9)	5.4 (11.3)	13	98.0 (21.2)	4.4 (18.1)	4	
Female	400 (47.0)	32.9 (5.6)	- 2.6 (7.3)	- 8	31.2 (12.6)	- 4.8 (15.5)	- 15	25.0 (20.8)	6.8 (12.1)	27	44.4 (19.8)	4.4 (14.4)	10	100.4 (20.3)	5.7 (20.9)	6	
Partner																	
Yes	600 (70.5)	35.3 (5.5)	- 2.1 (7.1)	- 6	35.3 (13.3)	- 5.0 (14.9)	- 14	22.6 (18.0)	6.4 (9.8)	28	41.1 (18.3)	4.3 (11.6)	11	98.8 (21.3)	4.9 (19.2)	5	
No	251 (29.5)	35.2 (5.1)	- 3.5 (8.6)	- 10	33.8 (12.1)	- 4.5 (14.9)	- 13	17.7 (16.8)	3.9 (10.5)	22	48.6 (20.7)	6.4 (15.2)	13	99.9 (19.6)	5.2 (20.1)	5	
Children at home																	
Yes	302 (35.5)	34.3 (5.8)	- 2.2 (7.2)	- 6	31.6 (13.9)	- 4.5 (13.7)	- 14	33.6 (21.7)	9.2 (12.9)	27	36.8 (16.9)	3.1 (12.3)	8	101.8 (21.4)	7.4 (20.0)	7	
No	549 (64.5)	35.7 (5.1)	- 2.7 (7.9)	- 7	36.6 (12.1)	- 5.0 (15.5)	- 14	14.3 (10.0)	3.7 (7.4)	26	46.9 (19.7)	6.0 (13.0)	13	97.7 (20.3)	3.7 (19.1)	4	
Age of children (years) ^a																	
0–3	93 (10.9)	33.2 (6.0)	- 3.6 (9.1)	- 11	27.6 (11.3)	- 6.2 (15.2)	- 22	42.5 (22.1)	11.3 (16.4)	27	35.7 (16.3)	3.4 (9.2)	10	105.5 (20.8)	7.9 (20.4)	8	
4–12	153 (18.0)	34.0 (6.0)	- 1.8 (7.3)	- 5	29.9 (13.2)	- 2.9 (13.7)	- 10	37.5 (22.6)	10.3 (14.5)	27	34.0 (16.8)	2.1 (9.1)	6	101.0 (21.6)	9.4 (19.2)	9	
13–17	131 (15.4)	35.3 (5.8)	- 2.4 (7.7)	- 7	34.9 (15.6)	- 5.5 (14.3)	- 16	26.1 (19.1)	7.0 (8.8)	27	38.9 (17.1)	4.1 (15)	11	99.5 (21.5)	5.6 (19.3)	6	
Education																	
High	522 (61.3)	35.3 (5.4)	- 2.1 (7.4)	- 6	35.3 (13.9)	- 4.7 (15.6)	- 13	21.8 (18.2)	6.4 (11)	29	42.5 (18.9)	4.8 (12.2)	11	99.5 (21.1)	5.4 (20.3)	5	
Middle	289 (34.0)	35.2 (5.3)	- 3.0 (7.6)	- 8	34.7 (11.2)	- 5.0 (13.9)	- 14	19.8 (16.6)	4.6 (8.3)	23	44.6 (19.2)	5.5 (13.2)	12	98.9 (19.5)	4.9 (17.7)	5	
Low	40.0 (4.7)	33.9 (5.6)	- 4.2 (9.9)	- 12	30.1 (12.5)	- 5.7 (12.5)	- 19	22.0 (21.2)	4.1 (7.6)	19	44.9 (25.9)	2.4 (17.7)	5	96.2 (26.0)	0.6 (20.6)	1	
Crucial job																	
Yes	241 (28.3)	34.3 (5.3)	- 2.5 (8)	- 7	35.8 (13.1)	- 4.8 (14.8)	- 13	19.6 (16.4)	5.3 (9)	27	43.0 (19)	5.1 (12.2)	12	98.2 (20.2)	4.9 (18.5)	5	
No	571 (67.1)	35.6 (5.7)	- 2.6 (7.3)	- 7	31.8 (11.4)	- 4.7 (14.6)	- 15	25.3 (20.4)	6.5 (12.6)	26	44.2 (20.0)	5 (14.2)	11	101.0 (22.3)	6.1 (21.1)	6	
Don't know	39 (4.6)	35.8 (4.6)	- 1.0 (3.5)	- 3	39.4 (17.4)	- 6.7 (18.7)	- 17	18.6 (16.1)	5.3 (7.1)	28	42.8 (20.6)	1.4 (13.1)	3	100.8 (19.5)	0.0 (22.5)	0	
Net income (t_0)																	
< €2000	92 (10.8)	31.8 (5.8)	- 4.6 (10.5)	- 14	29.0 (9.1)	- 5.1 (12.0)	- 17	19.2 (18.2)	3.9 (8.9)	20	50.3 (22.2)	7.4 (16.8)	15	98.2 (20.8)	5.6 (19.0)	6	
€2000–€3000	235 (27.6)	35.7 (4.6)	- 2.7 (7.5)	- 7	35.2 (13)	- 4.4 (16.8)	- 13	19.9 (17.7)	4.9 (12)	25	44.8 (20.5)	5.8 (12.0)	13	99.7 (20.9)	5.4 (20.1)	5	
€3000–€4000	172 (20.2)	35.6 (5.3)	- 2.1 (6.9)	- 6	34.5 (12.3)	- 4.1 (14.3)	- 12	22.2 (18.2)	6.4 (8.9)	29	42.3 (18.2)	2.3 (11.5)	5	98.8 (20.9)	3.7 (19.2)	4	

Table 1 (continued)

Variable	N (%)	Paid work: contract		Paid work: actual		Unpaid work		Leisure		Total hours: actual				
		t_0 (SD)	Δt (SD)	t_0 (SD)	Δt (SD)	t_0 (SD)	Δt (SD)	t_0 (SD)	Δt (SD)	t_0 (SD)	Δt (SD)			
€4000– €5000	133 (15.6)	35.8 (4.9)	-1.8 (6.2)	35.6 (11.4)	-5.3 (13.9)	21.6 (16.8)	7.0 (9.4)	32	40.8 (15.9)	5.2 (14.7)	13	98.0 (20.0)	6.4 (19.8)	7
€5000+	84 (9.9)	36.3 (5.2)	-1.7 (8.6)	39.0 (16.2)	-5.5 (15.7)	23.3 (19.1)	6.9 (9.7)	30	38.9 (18.4)	3.5 (9.6)	9	100.8 (22.3)	3.4 (17.9)	3
Don't know	12 (1.4)	32.7 (5.7)	-1.3 (9.8)	34.0 (13.4)	-3.8 (15.0)	17.5 (20.2)	5.6 (7.8)	32	42.7 (16.0)	6.0 (11.7)	14	94.3 (11.8)	7.9 (21.4)	8
Rather not say	123 (14.5)	35.3 (6.3)	-2.6 (6.7)	35.4 (14.4)	-5.6 (14.5)	21.7 (17.2)	5.0 (9.1)	23	42.6 (19.5)	5.8 (12.3)	13	99.7 (21.2)	5.2 (19.7)	5
Separate office														
Yes, whole day	439 (51.6)	35.7 (5.1)	-1.7 (6.6)	36.4 (12.8)	-3.9 (14.9)	18.0 (14.7)	4.5 (7.9)	25	43.3 (19.5)	4.2 (11.1)	10	97.5 (21.0)	4.9 (17.7)	5
Yes, part of day	73 (8.6)	35.1 (5.3)	-3.5 (7.2)	33.1 (12.2)	-6.0 (12.9)	24.8 (18.3)	8.5 (10.4)	34	41.0 (15.3)	6.7 (13.9)	16	98.9 (18.8)	9.2 (18.4)	9
No	319 (37.5)	34.6 (5.7)	-3.3 (8.8)	33.0 (12.9)	-5.8 (15.3)	24.1 (20.6)	6.2 (11.7)	26	43.8 (19.6)	5.4 (14.5)	12	100.7 (20.3)	5.7 (20.7)	6

SD standard deviation

^aNumbers do not add up to 100% because not everybody in the sample had children and because the categories are not mutually exclusive

on unpaid work than men ($p = 0.002$), but in relative terms the increase was similar. Moreover, people with a partner spent more extra time on unpaid work than people without a partner ($p = 0.001$) and less on leisure ($p < 0.001$). A similar pattern is observed for people with and without children; in absolute terms, people with children spent more extra time on unpaid work ($p < 0.001$) and less extra time on leisure ($p = 0.002$) during lockdown.

Table 2 shows Pearson correlations between differences in time allocation to paid work (contract and actual hours), unpaid work and leisure activities. The correlation between changes in contract and actual hours of paid work was positive and the largest between activities. For the rest, small negative-to-negligible correlations were found between all changes in time allocated to activities, indicating that there was little compensation in time changes between activities. The latter is confirmed by the positive correlations, with the change in total hours indicating that respondents generally increased the total time spent on paid work, unpaid work and leisure during the lockdown.

3.2 Paid Work

A description of sample characteristics related to paid work is presented in Table 3, a description of the type of job and sector is presented in Table 7 of the "Appendix". As shown in Table 3, for about half of the respondents (53.3%), there were no or hardly any changes in their work (except for the fact that the inclusion criterion was at least 4 additional hours working at home). On average, these people had slightly higher productivity than before the lockdown. About a quarter (26.9%) reported (predominantly) working at home during the lockdown, and roughly 5% worked more or less hours, or performed a different type of work. There were multiple work-related changes for 12.3% of respondents, namely a combination of working at home, working more or less hours, or doing different types of work. Two percent lost their job or changed jobs. On average, any changes in work were associated with decreased productivity.

Slightly less than half of the sample (43.2%) reported the quantity of work they achieved was the same as before lockdown, 19.0% did more and 35.4% did less. Most respondents (73.8%) reported an equal quality of work as before lockdown, 8.3% reported a higher quality and 15.5% reported a lower quality. These changes in the quantity and quality of work were also reflected in changes in paid work productivity, as computed using the formula presented in the Methods section. On average, respondents commuted 65.6 minutes per day (standard deviation = 56.0) before the lockdown.

As shown by the linear regression results in Table 4, people without a partner were less productive during than before the COVID-19 lockdown ($p = 0.06$). Having children

Fig. 2 Density plots of time allocation per week: paid work, unpaid work and leisure

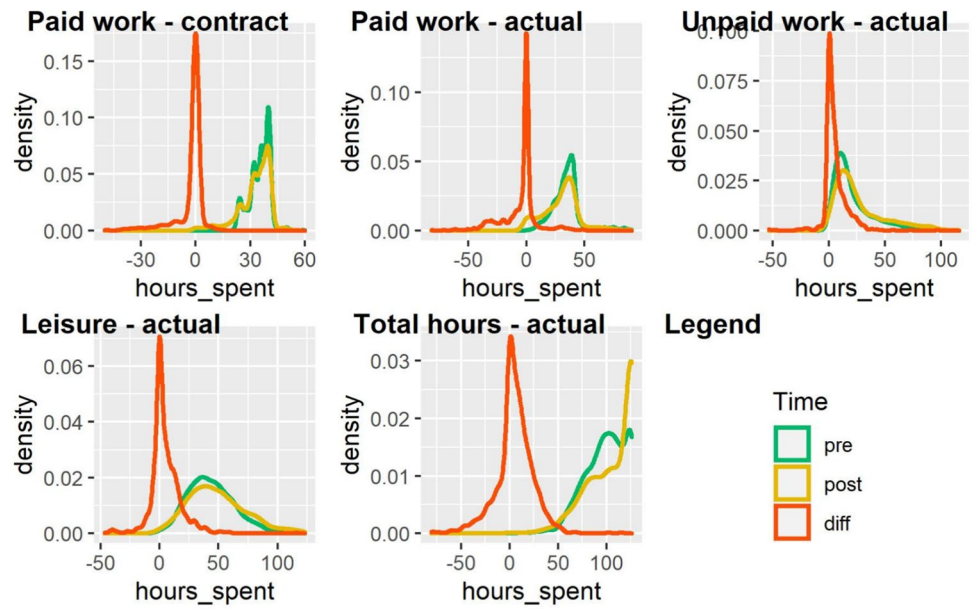


Table 2 Pearson correlations differences (Δt) in paid work, unpaid work and leisure

	Paid work: contract	Paid work: actual	Unpaid work	Leisure	Total hours: actual
Paid work: contract	1	0.51	- 0.10	- 0.23	0.20
Paid work: actual		1	- 0.15	- 0.23	0.56
Unpaid work			1	0.03	0.42
Leisure				1	0.51
Total hours: actual					1

Table 3 Sample characteristics paid work and productivity (Δt)

Variable	<i>N</i> (%)	Productivity (Δt), mean (SD)
<i>N</i>	851 (100)	94.5 (63.7)
Change in work	Same job, no changes	455 (53.5) 101.5 (60.0)
	Same job, (predominantly) work at home	229 (26.9) 97.8 (63.7)
	Same job, change in work hours/type of work	45 (5.3) 62.5 (62.4)
	Same job, multiple changes	105 (12.3) 77.1 (70.5)
	Lost or changed job	17 (2.0) -
Quantity work done	I could do an equal amount of work	368 (43.2) 94.2 (24.2)
	I could do more work	162 (19.0) 183.9 (76.0)
	I could do less work	301 (35.4) 49.1 (30.1)
	Not applicable	20 (2.4) -
Quality work done	My work was of equal quality	628 (73.8) 93.9 (41.5)
	My work was of higher quality	71 (8.3) 212.7 (103.1)
	My work was of lower quality	132 (15.5) 39.2 (29.5)
	Not applicable	20 (2.4) -
Commute in minutes per day, mean (SD)	65.6 (56.0)	-

SD standard deviation

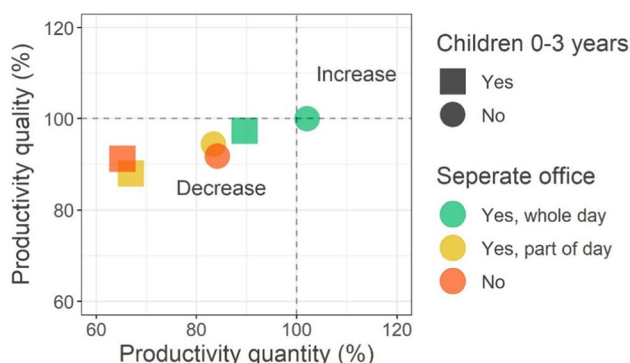
Table 4 Linear regression results: productivity (Δt) paid work ($N = 831$)

Variable		Estimate	Std. error	Statistic	<i>p</i> value
(Intercept)		75.25	26.33	2.86	< 0.01
Age (years)	18–34				
	35–49	10.11	6.01	1.68	0.09
	50–67	– 4.77	6.12	– 0.78	0.44
Gender	Male				
	Female	1.05	4.69	0.22	0.82
Partner	Yes				
	No	– 10.81	5.69	– 1.90	0.06
Children at home	Yes				
	No	2.90	11.44	0.25	0.80
Age of children (years) ^a	0–3	26.37	10.59	2.49	0.01
	4–12	– 1.21	9.05	– 0.13	0.89
	13–17	0.87	10.21	0.09	0.93
Education	High				
	Middle	– 5.38	4.87	– 1.11	0.27
	Low	– 5.72	10.55	– 0.54	0.59
Net income (t_0)	< €1999				
	€2000–€2999	11.09	7.97	1.39	0.16
	€3000–€3999	5.36	8.92	0.60	0.55
	€4000–€4999	9.03	9.55	0.95	0.34
	≥ €5000	21.70	10.73	2.02	0.04
	Don't know, rather not say	16.76	9.11	1.84	0.07
Separate office	Yes, whole day				
	Yes, a part of the day	– 32.13	7.92	– 4.06	< 0.01
	No	– 22.67	4.70	– 4.82	< 0.01
R-squared		0.08			

Std. standard

^aThe categories are not mutually exclusive, as people may have children in different age groups, thus the reference category differs per age group. For example, for “children aged 0–3 years”, the reference category is “no children aged 0–3 years”. Whether people have children is captured by the variable children (yes/no)

at home was associated with a statistically significant lower productivity only if there were children aged between 0 and 3 years ($p = 0.01$). A net monthly household income



Note: Total number of observations included = 831

Fig. 3 Average productivity (Δt) per subgroup: children aged 0–3 years (yes/no) and separate office

of €5000 or higher was associated with a higher productivity ($p = 0.04$) as compared with the change in productivity of respondents with an income below €2000. Furthermore, respondents who could avail of a separate office at home for the whole day had a higher productivity than those without an office, or an office for a part of the day only ($p < 0.01$). The R^2 (0.08) indicates that only a small percentage of the variance in productivity is explained by the model.

Fig. 3 highlights the differences in productivity during lockdown between respondents with or without children aged between 0 and 3 years and with or without a separate office at home. Respondents without children in the youngest age category and with a separate office had, on average, the highest productivity during lockdown, followed by respondents with children in the youngest age category and a separate office. Productivity was lowest for respondents with children in the youngest age category but no separate office, or only for a part of the day. The figure also shows that for these groups,

Table 5 Time allocation per week: unpaid work and leisure

Type of activity	t_0	Δt	$\Delta t(\%)$
Unpaid_{a,t}			
Support child education	1.5	0.9	58
Jobs around the house/garden	2.7	1.3	48
Informal care household member	0.4	0.1	27
Informal care others	0.6	0.2	25
Childcare	6.6	1.7	25
Household work	4.7	1.0	22
Prepare meals	4.2	0.8	19
Volunteer work	0.4	0.0	5
Total	21.1	5.7	27
Leisure_{a,t}			
Relax alone	6.1	1.4	23
Relax with household member	5.8	1.2	21
Social media and the Internet	8.4	1.7	20
Watch TV (including streaming)	12.5	2.2	18
Moderate exercise	4.2	0.7	16
Intense exercise	1.3	0.2	13
Contact friends	2.4	- 0.4	- 15
Contact family	2.7	- 0.7	- 27
Total	43.3	4.9	11

the decrease in the quantity of work had more impact on productivity than the decrease in the quality of work.

3.3 Unpaid Work

Table 5 provides a more detailed overview of how respondents allocated their time before the COVID-19 pandemic and how this changed since they were advised to work at home during the pandemic. As can be seen in the table, on average, more time was spent on all types of unpaid work, with a total of 5.7 h extra per week. Relatively most extra time was spent on supporting children with their education (58% more time) and on chores (48%). There was only a marginal increase in volunteer work (2%). In absolute numbers, most extra hours were spent on childcare (1.7 h), but time spent on chores as well as childcare also increased considerably, with 1.3 and 1.0 on average, respectively.

Figure 4 shows how time allocation to unpaid work differed for men and women and for people with children in the different age categories. The top figure illustrates how men with children spent more extra time on chores and preparing meals than women with children, while women with children spent more extra time on all other types on unpaid work. For people without children, most extra time was spent on chores, household work and preparing meals, in all these cases, women spent more extra time than men.

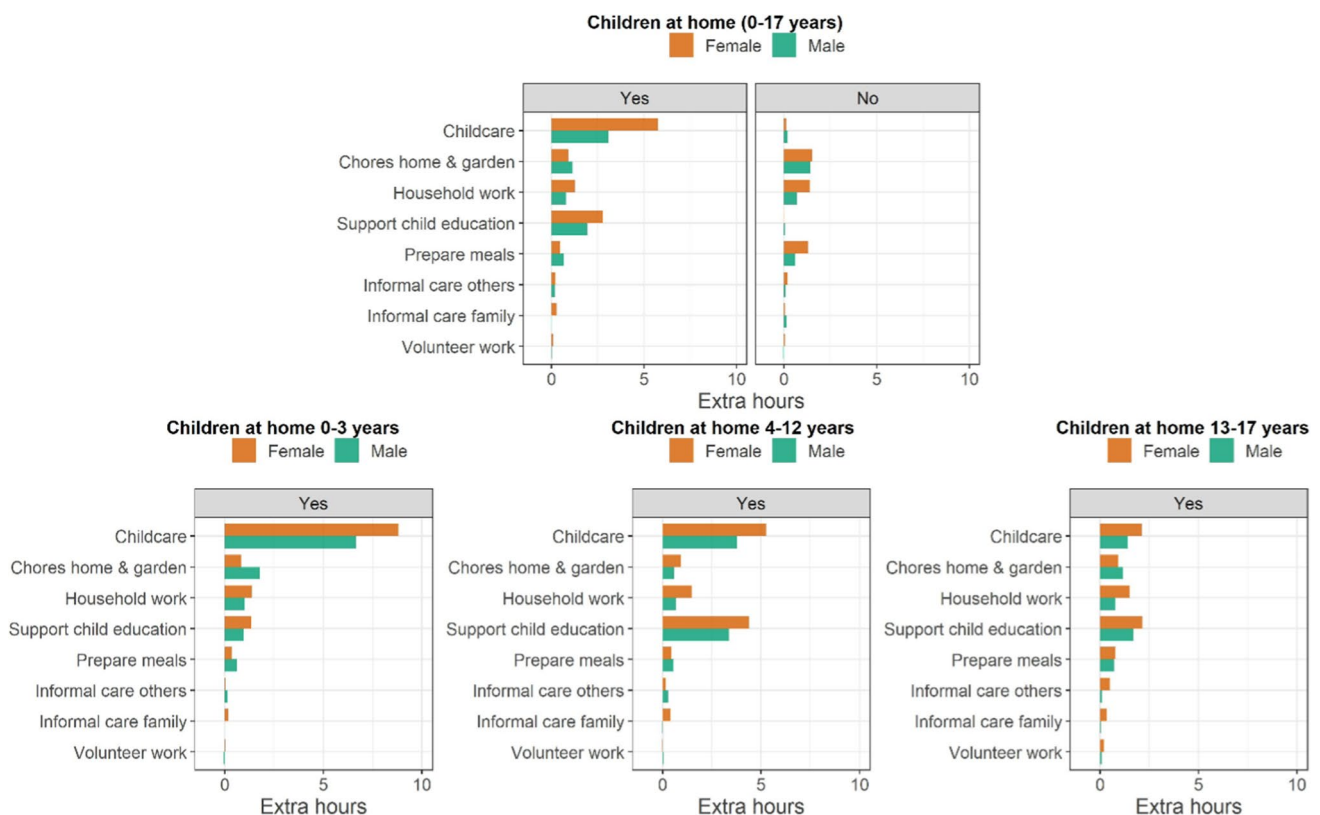


Fig. 4 Time allocation of unpaid work per subgroup (Δt): children at home (by age) and gender

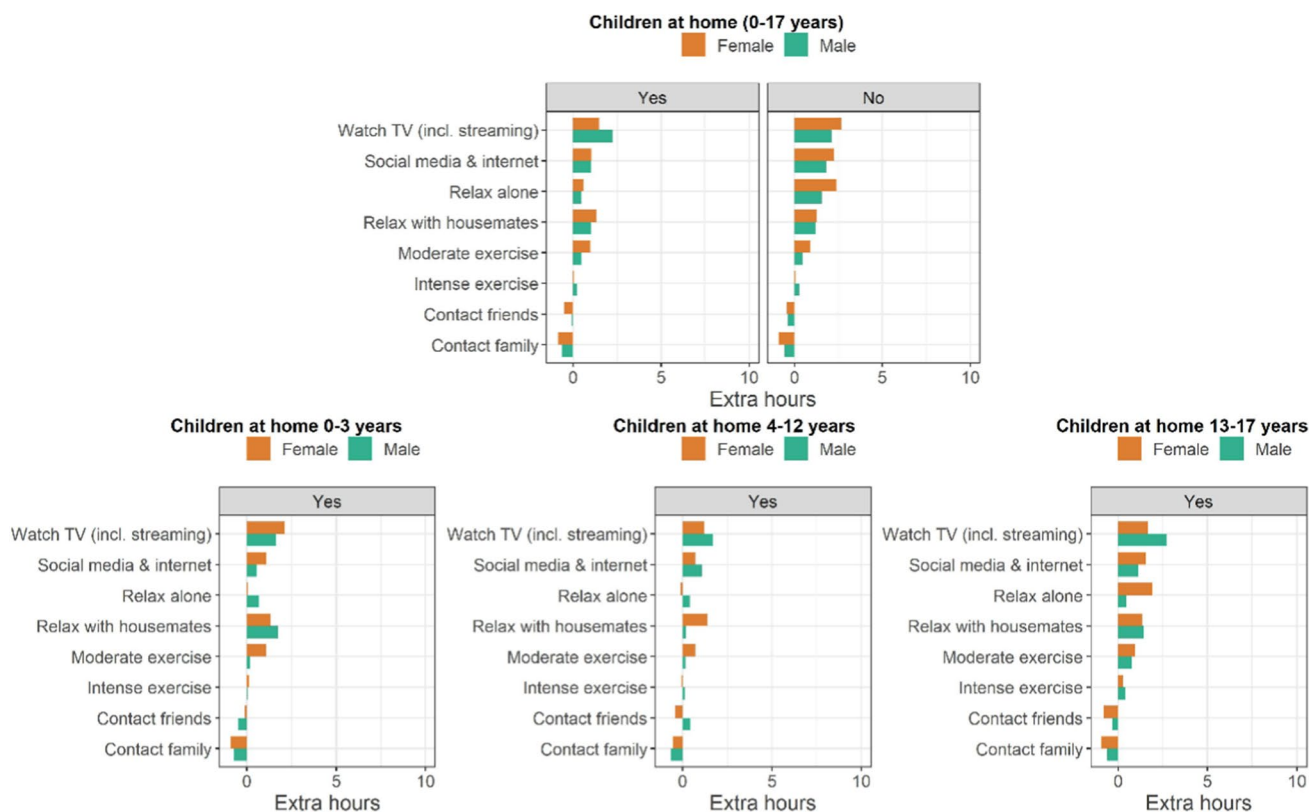


Fig. 5 Time allocation of leisure per subgroup (Δt): children at home (by age) and gender. *incl.* including

The bottom-left figure shows extra time spent on unpaid work for respondents with children in nursery school age. Most extra time was spent on childcare, and women spent more extra time on this than men. Men spent more extra time on chores and on preparing meals. Respondents with children in primary school age (bottom-middle) spent most of their extra hours of unpaid work on supporting children with their education and on childcare. Women spent more time on both activities than men. The bottom-right figure shows that for people with children in secondary school age, the distribution of extra time spent on unpaid work was more balanced between activities. Most extra time was spent on supporting children with their education, and more so by female than by male individuals. However, in general, the amount of extra time spent on any activity was lower than in the groups of people with younger children.

3.4 Leisure

Table 5 also shows the extra time was spent on most types of leisure activities during lockdown, with a total of 4.9 h extra per week. In relative terms, most extra time was spent on relaxing alone or with household members (23% and 21%). In absolute numbers, most extra hours were spent on watching TV and on social media and the Internet. Less time was

spent on contact with family (27%) and friends (15%), which is in line with the imposed lockdown measures.

Figure 5 illustrates how extra time allocation to leisure differed for men and women and for people with and without children. Consistent with the data presented in Table 1, the top figure shows that people without children generally spent more extra time on leisure activities than people with children. This holds especially for female individuals spending extra time on watching TV, social media and the Internet, and relaxing alone. The bottom figures highlight the changes for people with children in the different age groups. The bottom-left figure shows that people with children in nursery school age spent most additional time on watching TV and relaxing with other household members. Female individuals spent more extra on watching TV and on moderate exercise, and male individuals spent more extra time on relaxing with other household members. People with children in primary school age (bottom-middle figure) on average spent least additional time on leisure as compared with people with children in the other age groups. Female individuals spent most additional time on relaxing with household members and male individuals spent most additional time on watching TV. In the group of respondents with children in secondary school age, generally more time was spent on all leisure activities than people with children in the other age groups. Female individuals spent

most additional time on relaxing at home, male individuals on watching TV.

4 Discussion

This is one of the first studies assessing the impact of COVID-19 and lockdown restrictions on the productivity of paid work and time allocation to paid and unpaid work as well as leisure in the context of working at home in a sample of the general working population. For paid work, we found that contract hours and actual hours worked both decreased during the lockdown, but the number of actual hours decreased more sharply. Losses in contract hours were largest for respondents with a low income, low education and for people with young children. The amount of time spent on unpaid work and leisure on average increased, as well as the total amount of reported hours per week spent on all activities together (i.e. paid work, unpaid work and leisure activities). Correlations between the different types of time allocation were relatively low, suggesting little compensation behaviour, perhaps because people increased total (productive) time. People with young children, people who did not have a separate office for the entire day and people with low incomes had the largest decrease in productivity of paid work. Furthermore, women spent more extra time on unpaid work in absolute terms although not in relative terms. People with a partner and with children spent more additional time on unpaid work, and less on leisure than their counterparts.

The body of literature on the impact of COVID-19 on productivity is growing, but currently limited to specific sectors. As was found in the current study, a study among US residents also observed that productivity decreased during the COVID-19 pandemic [21]. Contrary to the US study, our study did not find a significant effect of gender on change in productivity. This might be due to differences in the measurement of productivity: in the current study, this was a numerical composite of self-reported quantity and quality of work, whereas the US study used a three-item self-assessed Likert scale to assess productivity. The observation that the number of working hours reduced was also found in a Canadian study [15]. Furthermore, Collins et al. [13] performed a study in the USA and found that mothers with young children had reduced their working hours four to five times more often than fathers. Consequently, the gender gap in work hours grew by 20–50%. We did find a gender gap in working hours prior to the pandemic, but it did not increase during the pandemic. On the contrary, in absolute terms, we found a larger decrease in work hours (contract and actual) for male individuals, but it was only slightly larger in relative terms. Perhaps these different findings between countries can be explained by the different cultures regarding gender roles for paid and unpaid work, as well as social security arrangements and specific support measures during the pandemic. Like the current study, earlier studies in the Netherlands and the USA

found that mothers provided more (additional) hours of childcare than fathers during the COVID-19 pandemic [8, 14].

Despite this study's contribution to the growing body of literature on the experiences of working at home during the pandemic, it also comes with some limitations. First, respondents with a high education level were strongly over-represented in our sample. Given our finding that people with a low income and low education in our sample lost most contract hours, the findings of this study may not generalise to the overall working population. The overrepresentation of highly educated individuals might be due to the inclusion criteria of the study, i.e. working at least 24 h per week and the ability to work at home. Lower educated people more often work in professions that do not allow working at home [3], also making them more vulnerable for infection with COVID-19. In addition, the data were collected using an online survey, which could have contributed to a higher response rate among respondents with a higher education. Second, on average, total hours reported (paid work, unpaid work and leisure) increased during the COVID-19 pandemic, that is, the increase in unpaid work and leisure outweighed the decrease in paid work. The increase in total hours partially originated from time saved by not having to commute and might also originate from a decrease in sleeping hours, the latter was not measured in the survey. Another explanation could be that respondents had difficulties recalling their time allocation for a full week, particularly also before the COVID-19 pandemic. A diary method, asking respondents to record their activities over the whole day for a 1-week period, might have provided more precise estimates, but was expected to have low response rates (especially during the first lockdown) and would have been more costly. Third, contrary to studies assessing productivity from an employer perspective [3, 22], in this study, workers self-assessed their productivity. While employers can only assess worked hours and productivity to a certain extent, workers themselves can provide valuable information about a number of other aspects importantly related to productivity (e.g. working conditions at home, time spent on unpaid work and leisure activities), which are difficult to evaluate for employers. Additionally, the regression analysis had a low goodness of fit. It might be explained by the sample size, by the multiple different components captured in our measure of productivity or by the highly stochastic nature of the concept productivity. However, given the descriptive nature of the paper, and the fact that the regression confirms our descriptive results, we deem it not to be problematic. Last, cross-sectional data were collected at an early stage of the COVID-19 pandemic when a partial lockdown was effective in the Netherlands, with a variety of measures to prevent the spread of COVID-19. The results presented here are thus specific to the context of the initial stage of the pandemic and the measures implemented by government,

Table 6 Data transformations, in order of appearance

Rule	Condition	Transformation	$N(t_0)$	$N(t_1)$	$N(\Delta t)$
1	Actual hours _{<i>t</i>} < 0	Actual hours _{<i>t</i>} = 0	0	13	
2	Unpaid _{<i>a,t</i>} < 0 or Leisure _{<i>a,t</i>} < 0	Unpaid _{<i>a,t</i>} = 0 or Leisure _{<i>a,t</i>} = 0	0	404	
3	\sum Paid, unpaid, leisure _{<i>t</i>} > 126	$\frac{\text{Actual hours}_{a,t}}{\max(\sum \text{Paid,unpaid,leisure}_{t_0} \& \sum \text{Paid,unpaid,leisure}_{t_1})} \times 126$ $\frac{\text{Unpaid}_{a,t}}{\max(\sum \text{Paid,unpaid,leisure}_{t_0} \& \sum \text{Paid,unpaid,leisure}_{t_1})} \times 126, \text{ and}$ $\frac{\text{Leisure}_{a,t}}{\max(\sum \text{Paid,unpaid,leisure}_{t_0} \& \sum \text{Paid,unpaid,leisure}_{t_1})} \times 126, \text{ such}$ that $\sum \text{Paid,unpaid,leisure}_{t_1} = 126$	262	314	
4	Actual hours _{<i>t_1</i>} = 0	Productivity _{Δt} = 0%			24

Table 7 Characteristics of paid work

Variable	N (%)
N	851 (100)
Type of job	
Administrative	213 (25.0)
Artisanal	11 (1.3)
Commercial	91 (10.7)
Healthcare and social care	75 (8.8)
Managerial	77 (9.0)
Service provision	117 (13.7)
Professional specialist, e.g. architect, IT specialist, artist	113 (13.3)
Teaching	69 (8.1)
Transport	21 (2.5)
Other	64 (7.5)
Sector	
Agriculture and green sector	5 (0.6)
Building industry	19 (2.2)
Education	99 (11.6)
Financial services	93 (10.9)
Food service, catering and tourism	16 (1.9)
Healthcare	81 (9.5)
Industry	61 (7.2)
Installation sector	12 (1.4)
Public sector	118 (13.9)
Retail	36 (4.2)
Social work, youth care and day care	47 (5.5)
Transport and logistics	56 (6.6)
Web shops	12 (1.4)
Wholesale	32 (3.8)
Other	164 (19.3)

employers and workers themselves, and may not hold for other countries or other periods. For instance, at the time of the data collection for this study, schools and day care centres for children were closed, and the government strongly advised to work at home. In addition, cultural differences (for instance, with regard to gender roles in paid and unpaid work) can result in differences between countries. Moreover, when people become more accustomed to working at home, this may help to increase productivity in the long term.

It is also worthwhile to highlight the broader relevance of the current study in the context of economic evaluations of healthcare interventions. When using a societal perspective, the presented effects on the productivity of working at home may be of direct relevance in economic evaluations of vaccination strategies and other measures to reduce the impact of COVID-19. They also highlight the relevance of productivity changes in the context of health problems that may force people to work at home more frequently (e.g. contagious diseases or immobility). Absence from work in those contexts does not necessarily imply a full loss, but also not a full continuation of productivity; as our analysis shows, it may depend on, for example, the composition of the household and the availability of an appropriate working place. This emphasises the need for sound and more refined measures of productivity in paid and unpaid work for use in economic evaluations, which is even more important if working at home becomes more common in the future.

5 Conclusions

This study showed that the COVID-19 pandemic and subsequent lockdown measures in the Netherlands have resulted in less time allocated to paid work and more time allocated to unpaid work and leisure activities. For most people,

productivity of paid work decreased during the first lockdown, except for people who could avail of a separate office at home for the entire day. Employers could facilitate better working conditions at home to enhance productivity during future lockdowns, and in a post-pandemic situation when working at home might become more standard. People with children were particularly affected during the first lockdown, when schools and day care were closed, and parents had to allocate more time to teaching and caring tasks for their children. Specific attention for this group is essential if future lockdowns also entail the closing of schools and day care centres.

Following a recent policy letter by Yerkes et al. [23], future research should focus on the long-term impact of the lockdown on productivity, and on how productivity will be affected when lockdown measures are alleviated. They found that, by November 2020, working hours were back to the level before the COVID-19 pandemic, but that people still experienced more work pressure. Furthermore, regardless of an initial increase, the percentage of fathers who spent more time on childcare had decreased. They also found that people with young children were better at combining work and care than before. People's experiences during the first waves of the COVID-19 pandemic, adapted expectations or circumstances, and the long duration of lockdown restrictions could impact people's time allocation as well. In addition, future studies could focus on the impact of the changing work circumstances during and after the pandemic on mental health (e.g. burn outs) and physical health (e.g. ergonomic injuries), and on job satisfaction and worker well-being more in general.

Appendix

The data transformations that were performed before the analysis are presented in Table 6. They were performed with the goal of presenting an accurate representation of results and were applied in order of appearance. The number of hours spent on a particular type of unpaid work is referred to as $\text{Unpaid}_{a,t}$ for activity a at time t . Time spent on leisure activities follows the same notation as for unpaid work, namely $\text{Leisure}_{a,t}$ which refers to activity a at time t . The sum of actual hours spent on all activities, i.e. $\sum \text{Actual hours}_t + \sum \text{Unpaid}_{a,t} + \sum \text{Leisure}_{a,t}$, is defined as $\sum \text{Paid, unpaid, leisure}_t$ for brevity. Rules 1–3 were performed as the scenarios described in these rules were highly unlikely or practically impossible². To

² Some respondents allocated spending a lot of time on the inquired activities, some even more than 24 hours per day, 7 days a week. As respondents also need time for basic needs such as personal care and sleep, we have set a limit to 18 hours per day (i.e. 126 hours per week) following informal care research [24–27].

clarify the transformation in rule 3, imagine someone reported 240 hours at t_0 and 300 at t_1 . To guarantee that neither $\sum \text{Paid, unpaid, leisure}_{t_0}$ nor $\sum \text{Paid, unpaid, leisure}_{t_1}$ exceed 126 hours, while safeguarding an increase in t_1 as compared to t_0 , values are rescaled to the maximum of $\sum \text{Paid, unpaid, leisure}_{t_0}$ and $\sum \text{Paid, unpaid, leisure}_{t_1}$. If, in this example, the respondent performed 40 hours of unpaid work at t_0 , and 60 hours at t_1 , these values are rescaled to 16.8 ($=40/300 \times 126$) and 25.2 ($=60/300 \times 126$), respectively. The rescaled total amount of hours spent on all activities is 100.8 ($=240/300 \times 126$) hours at t_0 , and 126 ($=300/300 \times 126$) at t_1 . Rule 4 was introduced because of routing; respondents skipped some questions that were used to calculate productivity if they reported to not have worked at t_1 (Table 7).

Declarations

Funding The first author has received funding from the Erasmus Initiative “Smarter Choices for Better Health.”

Conflict of Interest None of the authors report conflicting interests.

Ethics Approval The study was approved by the Ethical Review Committee of Erasmus School of Health Policy & Management (IRB 20-12).

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Availability of Data and Material Data are available upon request.

Code Availability The code is available upon request.

Author Contributions AS, LH-vR, WB and JvE contributed to the study conception, design and material preparation. Data collection was overseen by LH-vR. Initial data cleaning was performed by AS and JvE, and further cleaning and analyses were performed by SH. The manuscript was jointly written, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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