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The impact of COVID-19 pandemic on gender-related work from home in STEM fields—Report of the WiMPBME Task Group

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Abstract

The COVID-19 pandemic has forced many people, including those in the fields of science and engineering, to work from home. The new working environment caused by the pandemic is assumed to have a different impact on the amount of work that women and men can do from home. Particularly, if the major burden of child and other types of care is still predominantly on the shoulders of women. As such, a survey was conducted to assess the main issues that biomedical engineers, medical physicists (academics and professionals), and other similar professionals have been facing when working from home during the pandemic. A survey was created and disseminated worldwide. It originated from a committee of International Union for Physical and Engineering Sciences in Medicine (IUPESM; Women in

Medical Physics and Biomedical Engineering Task Group) and supported by the Union. The ethics clearance was received from Carleton University. The survey was deployed on the Survey Monkey platform and the results were analyzed using IBM SPSS software. The analyses mainly consisted of frequency of the demographic parameters and the cross-tabulation of gender with all relevant variables describing the impact of work at home. A total of 921 responses from biomedical professions in 76 countries were received: 339 males, 573 females, and nine prefer-not-to-say/other. Regarding marital/partnership status, 85% of males were married or in partnership, and 15% were single, whereas 72% of females were married or in partnership, and 26% were single. More women were working from home during the pandemic (68%) versus 50% of men. More men had access to an office at home (68%) versus 64% for women. The proportion of men spending more than 3 h on child care and schooling per day was 12%, while for women it was 22%; for household duties, 8% of men spent more than 3 h; for women, this was 12.5%. It is interesting to note that 44% of men spent between 1 and 3 h per day on household duties, while for women, it was 55%. The high number of survey responses can be considered excellent. It is interesting to note that men participate in childcare and household duties in a relatively high percentage; although this corresponds to less hours daily than for women. It is far more than can be found 2 and 3 decades ago. This may reflect the situation in the developed countries only—as majority of responses (75%) was received from these countries. It is evident that the burden of childcare and household duties will have a negative impact on the careers of women if the burden is not more similar for both sexes. It is important to recognize that a change in policies of organizations that hire them may be required to provide accommodation and compensation to minimize the negative impact on the professional status and career of men and women who work in STEM fields.

KEYWORDS
biomedical engineers, COVID-19 pandemic, gender balance, medical physics, survey, working from home

1 | INTRODUCTION

During the COVID-19 pandemic, many professionals in science and engineering began to work from home. Many universities developed policies for faculty, students, and staff to stay off-campus and work from home. This created a new work environment, especially for professionals with young children at home who had to be home-schooled. This was also challenging for families looking after the elderly and disabled persons. The assumption that motivated the development of the survey was that the pandemic may be having a different impact on the amount of work that women and men could do from home if the major burden of child and other types of care is still predominantly on the shoulders of women. If this was found to be true, then there would be a need for organizations to understand the situation and develop measures that compensate for this gender discrepancy.

1.1 | Literature review

Brynjolfsson et al. (2020) report the results of a nationally representative sample of the US population during the COVID-19 pandemic. The authors distributed the survey during two periods: April 1–5, 2020, and May 2–8, 2020. Around half of people employed in a pre-COVID-19 period were now working from home (WFH); this included 35.2% who reported they were commuting and recently switched to working from home and 10.1% who reported being laid-off or furloughed since the start of the pandemic. The authors found a strong negative relationship between the proportion still commuting to work and the proportion working from home; that is the proportion of people switching to working remotely could be predicted by the occurrence of COVID-19; they also found that younger people were more likely to choose remote work. Not surprisingly, in the States where there was a higher proportion of employment in information work, professional and related occupations were more likely to work from home, and fewer people were laid off or furloughed. There was no substantial change between the results collected in April or May (Brynjolfsson et al., 2020).

Bick et al. (2020) report the results of a new survey: 35.2% of the US workforce worked entirely from home in May 2020, compared to 8.2% in February. The authors found that workers who were more likely to work from home during the pandemic, and maintain their employment, were the highly educated, high-income, and white workers. They also found that 71.7% of workers who could work from home did so in May.

Kramer and Kramer (2020) discussed three occupationally related domains that may be impacted by the pandemic; they state: "perceptions of the value and status of different occupations may change, resulting in both changes of occupational supply and demand (macro changes) and changes in the perceived calling and meaningfulness of different occupations (micro-changes)." They also claimed that the "work from home experiment may change occupational perspectives on working from home … and that organizations and researchers may be able to better understand which occupational and individual characteristics are associated with work-from-home effectiveness and better designate occupational groups and individuals to working (or not working) from home." Finally, they discussed the increased division of the labor market which assign workers to "good jobs" and "bad jobs" and the contribution of occupational segmentation to inequality (Kramer & Kramer, 2020).

Bonacini et al. (2021) discussed how WFH became of great importance for a large share of employees to minimize exposure to the virus; it was also the only choice for many people to continue working. Companies began to consider WFH as a new normal since the duration of the pandemic is uncertain. The authors used influence function regression methods to explore "the potential consequences in the labor income distribution related to a long-lasting increase in WFH feasibility among Italian employees." They found that an increase in the proportion of people working from home would be associated with an increase in average labor income, but this potential benefit would favor male, older, high-educated, and high-paid employees and employees living in provinces. They concluded, "WFH thus risks exacerbating pre-existing inequalities in the labor market, especially if it will not be adequately regulated." Their study suggested that "policies aimed at alleviating inequality, like income support

measures (in the short run) and human capital interventions (in the long run), should play a more important compensating role in the future" (Bonacini et al., 2021).

The study by Raišienė et al. (2020) examined the evaluation of telework through a questionnaire by different groups of 436 teleworkers in Lithuania. Through a correlation analysis between the study variables, the findings suggested that there were disparities in the assessment of factors affecting telework efficiency and qualities required from a remote worker, as a function of gender, age, education, work experience, and experience of telework. In summary, the authors found that women were more appreciative of the opportunity to work from home to ensure a healthier lifestyle, while men assessed WFH more negatively, owing to perceived role conflict, constraints on career opportunities, and changes in employment relationship dynamics. Moreover, the authors found that men stated more often than women that their work was distraught by other members of the household, which raised further concern regarding their competence, work performance, and assessment of their achievements. Men often argued that WFH restricted their prospects to demonstrate exceptional skills. Men also mentioned issues related to "information overload, time-consuming asynchronous communication, and tension due to the distribution of attention between work tasks and intense communication… and they were statistically more likely than women to face self-organizing challenges." Women stated that "the ability to work independently and time-management and communication skills are the most important qualities for successful teleworking… and believed that personal leadership qualities are essential when working from home." The authors concluded that, from the gender perspective, men considered that a successful career required a traditional "masculine" life. When faced with a stereotypically feminine situation in which home and work responsibilities need to be mutually accomplished with efficient time management, men often felt the threat to their work success (Raišienė et al., 2020).

The few studies cited above have focused on questions addressing the general impacts of working from how without taking gender difference into account. Each article discusses interesting aspects of WFH during the pandemic but did not address the gender differences in the proportion spent in childrearing and household duties, or even access to home office, which can impact the careers of women and men. Furthermore, STEM field professionals such as academics/educators and clinical scientists might face different challenges while working from home as compared to other professions, which could further impact gender-related issues. Addressing this gap in the literature, the current study has investigated how working from home during the pandemic affected STEM field professionals (focusing on biomedical engineers and medical physicists) based on gender, looking at several aspects that reflect on work and non-work tasks alike: childcare/schooling, eldercare, household duties, and work-related challenges.

2 | METHODS

The work presented here has been conducted under the auspices of the International Union for Physical and Engineering Sciences in Medicine (IUPESM), the International Federation of Medical and Biological Engineering (IFMBE), and the International Organization for Medical Physics (IOMP).

Members of the Women in Medical Physics and Biomedical Engineering (WiMPBME) Task Group of the IUPESM developed an online cross-sectional survey that included demographic information on respondents, as well as details on the amount of time that women and men who worked from home would spend on duties other than their professional work. The survey was deployed on the SurveyMonkey platform and was disseminated worldwide through professional and personal email contacts of the Task Group members, web postings and social media of the organizations involved (IUPESM, IFMBE, IOMP). The effort was supported by the Executives of the IUPESM. An application for ethics clearance was made to the Ethics Office at Carleton University (Ethics Protocol Clearance ID: Project no. 112898). Participants were self-selecting; only respondents who agreed to participate after reading the consent information, were included in the survey. Most

of the survey questions (apart from the consent) were voluntary and as such, the number of responses can vary from question to question.

Those who did not consent were automatically exited from the survey after the consent page. The survey was closed at the end of August 2020.

The analyses were performed using the IBM-SPSS statistics 26 (IBM Corp., Released 2019. IBM SPSS Statistics for Windows, Version 26.0: IBM Corp.). It consisted of a frequency analysis of the demographic parameters, followed by a cross-tabulation of data and analysis by gender with all relevant variables describing the impact of work at home.

3 | RESULTS

3.1 | Demographic data

The survey dataset comprises 921 individuals from 76 countries and has reached global representation based on gender, age, race/ethnicity, and professional expertise. Seventy-five percent of respondents were from high-income countries and 25% from low-to-middle-income countries (The World Bank Data) (see Appendices A and B for country distribution). Of the respondents, 62.2% (573) were female and 36.8% (339) male, leaving less than 1% (9) to respondents who either preferred not to disclose or consider their gender different. As the number of prefer-not-to-say/other respondents was too low (approximately 1%) for any statistical significance, the following analyses use male and female data only.

Following the current ethical survey standards, most questions were voluntary and resulted in some questions that were unanswered. Regardless, the percentages in this section were calculated from the total of 921 participants. Hence, the total percent in tables may not sum up to 100% if the question was skipped or multiple answers were selected by some participants.

Table 1 presents the gender distribution of the respondents. The percentage shows predominant interest (nearly 2:1) in gender-work related topics among female respondents.

Most of the respondents answering the question on the relationship status were married (63.7%), an additional 12.7% in partnership status, leaving 21.6% single respondents, and 2% who did not disclose their relationship status (Table 2). While comparing the actual single-to-married distribution between female and male respondents, we registered different proportions in female (2.2:1) and male (5:1) respondents. The largest group of respondents in the survey constituted of married females (36% from the total 921 responses).

TABLE 1 Gender distribution of respondents

Gender	Male	Female	Other	Prefer not to say
Number of respondents	339	573	1	8
Percentage	36.8	62.2	0.1	0.9

TABLE 2 Distribution of respondents based on relationship status

Marital status	Single	Married	In Partnership	Prefer not to say
Number of respondents	199	587	117	18
Percentage	21.6	63.7	12.7	2.0
Number of female respondents	149	332	82	10
Number of male respondents	50	253	34	2

Respondents' age follows a nearly normal distribution (Table 3), with peaks in the lower middle-aged group (30–44 age range) with 501 participants (54.4%). The second-largest group of respondents is within the 45–59 years range (25.1%). The participation of young (11.9%) and 60+ (7.2%) aged professionals is less than 20%. A small amount of retired (1.1%) respondents has also contributed to the survey. The age bracket reflected majority of working population within the biomedical engineer and medical physicist communities.

Table 4 presents the racial/ethnic distribution of the respondents, which is quite expected and close to the distribution already reported by the professional organizations. Most of the participants in the survey belong to the Caucasian (46%) followed by South-East Asian (16.2%), East Asian (13.7%), and Hispanic/Latin (9.3%). The rest of the groups are represented by less than 5% each—South Asian (4%), African-American/Black (2.5%), Middle Eastern (1.6%), Pacific Islander (0.5%). A total of 4.3% of the survey participants have chosen not to disclose data, and another 5% have categorized themselves as belonging to other groups. Since more than one selection was possible, a small number, 30 (3.3%), have reported they belong to more than one racial/ethnic group.

The professional experience of the participants (Table 5) is of key importance regarding their expertise in the field and the ability to access/compare the working conditions pre- and during the pandemics. Respondents' distribution is relatively equal within the specified ranges, with most of the participants having over 20 years of experience (22.8%), followed by respondents with 5–10 years' experience (20.1%), 11–15 years (19.4%), less than 5 years (15.7%), and 16–20 years (11%). A 2.5% of the respondents have used the option to provide additional comments, most of which refer to retirement or parental leave.

Professional distribution of respondents is presented in Table 6, with most of them (57.3%) being Medical Physicists, a smaller group (15%) of Biomedical Engineers and 16.7% of other STEM professions. The Medical Physicists-Biomedical Engineers distribution does not correspond to the actual membership distribution within the professional organizations (approximately 27,000 medical physicists and 120,000 biomedical engineers, based on IUPESM data). Another important aspect is the Academic-Clinical distribution between the Medical Physicists and the Biomedical Engineers, which totals up to 19.4% versus 52.9%.

TABLE 3 Age distribution of respondents

Age group	18–29	30–44	45–59	60+	Retired	Prefer not to say
Number of respondents	110	501	231	66	10	3
Percentage	11.9	54.4	25.1	7.2	1.1	0.3

TABLE 4 Racial/ethnic distribution of respondents (more than one selection is possible)

Race/ethnicity	Number of respondents	Percentage
African-American/Black	23	2.5
Caucasian	424	46.0
East Asian	126	13.7
Hispanic/Latinx	86	9.3
Middle Eastern	15	1.6
Pacific Islander	5	0.5
South Asian	37	4.0
South East Asian	149	16.2
Prefer not to say	40	4.3
None of the above	46	5.0
Multiple selections	30	3.3

TABLE 5 Distribution of respondents by years of work as a Biomedical Engineering/Medical Physics professional or in another STEM field (including additional comments on current parental leave, retired, etc.)

Years of work	Under 5 years	5–10 years	11–15 years	16–20 years	More than 20 years	Additional comment
Number of respondents	145	185	179	101	210	23
Percentage	15.7	20.1	19.4	11.0	22.8	2.5

TABLE 6 Distribution of respondents by profession

	Academic		Clinical		
Profession	Biomedical Engineer	Medical Physicist	Biomedical Engineer	Medical Physicist	Other STEM fields
Number of respondents	81	98	57	430	154
Percentage	8.8	10.6	6.2	46.7	16.7

TABLE 7 Distribution of respondents by access to home office

Access to home office	Yes	No	Other
Number of respondents	543	249	28
Percentage	59.0	27.0	3.0
Number of female respondents	320 (59.6%)	150 (27.9%)	
Number of male respondents	218 (64.3%)	97 (28.6%)	

TABLE 8 Distribution of respondents by work from a home office as part of your regular work arrangement in non-COVID-19 times

Time worked from home	Yes 1 day a week	Yes 2 days a week	Yes 3 days a week	Yes 4 days a week	Yes 5 days a week	No	Other
Number of respondents	51	41	27	12	72	556	60
Percentage	5.5	4.5	2.9	1.3	7.8	60.4	6.5

Access to home office is a key factor during the pandemic (Table 7). Home office may be considered a protected remote environment to perform professional duties and facilitate professional growth/development. Most of the respondents (59%) have access to home office while 27% do not. What attracts attention are the actual numbers corresponding to female and male respondents' access to home office—59.6% of female and 64.3% of male respondents state they have access to home office.

The data associated with the prepandemic times (Table 8) show that 60.4% of the respondents did not perform any remote work, while 22% have worked remotely between 1 and 5 days a week. Although remote work has been a regular practice for 22%, the majority face it as a new way of work, associated with certain specifics/limitations.

The number of children living in the household presented in Table 9 is close to a normal distribution and expectedly corresponds to the age distribution of the respondents.

TABLE 9 Distribution of respondents by number of children living in household

Number of children	Less than 1 year old	Less than 3 years old	Between 3 and 6 years old	Between 7 and 10 years old	Between 11 and 14 years old	Between 15 and 18 years old	18 or older
Number of respondents	29	81	147	140	106	63	99

TABLE 10 Percentage of work done at home compared to proportion at the workplace (where minus % shows less work from home compared to the workplace and plus % shows more work from home as compared to office/workplace)

Work at home versus workplace (%)	−0% to 25%	−26% to 50%	−51% to 75%	−100%	+0% to 25%	+26% to 50%	+51% to 75%	+100%	Other
Number of respondents	97	53	28	13	58	44	68	87	42
Percentage	19.8	10.8	5.7	2.7	11.8	9.0	13.9	17.8	8.6

3.2 | Data regarding working from home during the pandemic

The information reported by males and females regarding working from home during the COVID-19 pandemic covered various aspects such as: the number of hours worked from home, the number of hours spent with other responsibilities while working from home (looking after children or the elderly) as well as the main challenges while working from home for both educators/academics and clinical scientists. To fulfill the aim of this research, the results are reported separately based on the answers supplied by female and male participants, respectively.

The percentages in this section were calculated from the total of 573 female or 339 male participants respectively. The total percent in tables may not sum up to 100% if the question was skipped by some participants.

3.2.1 | Female data

A total of 573 females participated in the survey. At the time of the questionnaire, 388 (67.7%) were working from home either in part or fully. This percentage varied during the pandemic, leading to a value of 80.9% of women working from home at a certain time period. While for some working from home resulted in higher efficiency, others had diminished productivity, meaning that they required additional time and effort to deliver the same amount of work as they would have at the workplace. Table 10 presents the average percentage of work done at home compared to the proportion at the workplace for the same job/task.

The efficiency of working from home (or lack of) is dependent upon several factors: work conditions (existence of home office, possibility to deliver the task with the available resources, communication with peers/students, optimal Internet connection, etc.), ambiance (ability to focus, interference from outside sources/people living in the same household, etc.), time management, additional preparation for online teaching, psychological aspects, and so on.

As probably expected, most women spent considerable hours with childcare/schooling and household duties, some also being involved in eldercare (Table 11). While 8.2% of the responders spent less than 1 h per day with childcare/schooling, 17.2% spent up to 3 h, 11.5% up to 6 h, and 10.2% spent over 6 h looking after their children. For these tasks, nearly half of the responders (47.5%) required certain adjustments to their working hours: 13.5% early morning, 18.3% late at night, and 15.7% other times during the day. Those involved in eldercare/disabled, including nontraditional care such as online well-being checks, reported various levels of

TABLE 11 Percentage of women involved in other than workplace-related duties: childcare, eldercare/disabled, household

Duties	Childcare/schooling	Eldercare	Household
Yes	47%	15.5%	87.9%
No	53%	84.5%	12.1%

TABLE 12 Comparative analysis of the percentage of academics versus clinical scientists regarding online teaching/research challenges

Challenge	No challenges	A little	Significant	Not applicable
Academics/educators	10.4%	28.7%	19.3%	41.7%
Clinical scientists	11%	28.5%	14.8%	45.7%

involvement: 27.8% spent less than 1 h with such activities, 16.3% spent up to 3 h, while 5.5% spent 6 or more hours per day looking after others (excluding their own children). Household duties were undertaken on a regular basis by 87.9% of women, with more than half (55%) spending up to 3 h daily with these tasks. Of all responders, 21.4% of women reported less than one hour spent with household duties, while 11.5% spent 6 or more hours (Table 11).

Online teaching has proven to be a challenge for a number of STEM field professionals, owing to various reasons. When comparing the answers provided by academics/educators and clinical scientists regarding challenges of online teaching, research or other activities delivered through the Internet during lockdown, the two groups showed great resemblance both concerning the challenges they were facing and the lack of (Table 12).

While about 11% of academics and clinical scientists found no particular difficulties with online teaching, student supervision, or other research activities, nearly 20% of educators and 15% of clinical scientists considered online activities challenging.

Time was a major factor in all aspects: time to learn new skills, time to convert lectures to suit online teaching, time to prepare new tasks adapted to e-learning platforms, time to prepare additional materials (including administrative work), time to spend with childcare, and so forth. Most clinical scientists were affected by the deferral of various clinical activities: collection of biological samples, preparation of radioisotopes, laboratory experiments, or even clinical trials. Clinical workflow often required updates to be handled remotely by multiple clinical teams.

3.2.2 | Male data

A total of 339 males participated in the survey, out of which, at the time of the questionnaire 169 (49.9%) were working from home either in part or fully. This percentage varied during the pandemic, leading to a value of 62.5% of men working from home at a certain time period. While for some, working from home resulted in higher efficiency, others had diminished productivity, meaning that they required additional time and effort to deliver the same amount of work as they would have at the workplace. Table 13 presents the average percentage of work done at home compared to the proportion at the workplace for the same job/task.

The efficiency of working from home (or lack of) is dependent upon several factors that are the same as for women working from home: work conditions (existence of home office, possibility to deliver the task with the available resources, communication with peers/student, optimal Internet connection, etc.), ambiance (ability to focus, interference from outside sources/people living in the same household, etc.), time management, additional preparation for online teaching, psychological aspects, and so on.

TABLE 13 Percentage of work done at home compared to proportion at the workplace (where minus % shows less work from home compared to the workplace and plus % shows more work from home as compared to office/workplace)

Work at home versus workplace (%)	−0% to 25%	−26% to 50%	−51% to 75%	−100%	+0% to 25%	+26% to 50%	+51% to 75%	+100%	Other
Number of respondents	86	23	19	15	43	28	34	33	38
Percentage	27.0	7.2	6.0	4.7	13.5	8.8	10.7	10.3	11.9

TABLE 14 Percentage of men involved in other than workplace-related duties: childcare, eldercare/disabled, household

Duties	Childcare/schooling	Eldercare	Household
Yes	41.5%	39.5%	74.1
No	58.5%	60.5%	25.9

TABLE 15 Comparative analysis of the percentage of academics versus clinical scientists regarding online teaching/research challenges

Challenge	No challenges	A little	Significant	Not applicable
Academics/educators	11.2%	28.3%	13.1%	47.4%
Clinical scientists	15.6%	27.4%	16.2%	40.8%

A large percentage on male responders spent considerable hours with childcare/schooling and household duties, some also being involved in eldercare (Table 14). While 10.9% of the responders spent less than 1 h a day with childcare/schooling, 18.4% spent up to 3 h, 8.2% up to 6 h, and 4.1% spent over 6 h looking after their children. For these tasks, more than one-third of the responders (38.1%) required certain adjustments to their working hours: 11.2% early morning, 14.6% late at night, and 12.2% other times during the day. Those involved in eldercare/disabled, including nontraditional care such as online well-being checks, reported various levels of involvement: 24.5% spent less than 1 h with such activities, 11.6% spent up to 3 h, while 2.7% spent up to 6 h and 0.7% spent 6 or more hours per day looking after others (excluding own children).

The answers provided by academics/educators and clinical scientists regarding challenges of online teaching, research or other activities delivered through the Internet during lockdown showed considerable similarities (Table 15). The main differences are connected with the work to be done. In particular, clinical scientists must spend some time at clinics, not all their work can be done remotely; one reason for this is the inaccessibility of patient data (hospital information system, PACS) from outside the hospital network due to security measures.

While about 11% of academics and 15% of clinical scientists found no particular difficulties with online teaching, student supervision, or other research activities, about 13% of educators and 16% of clinical scientists considered online activities challenging.

3.3 | Comparative data for female versus male regarding working from home during the pandemic

Figure 1 illustrates the comparative data between male and female STEM-field academics and clinicians regarding their involvement in activities other than office work, such as childcare, eldercare, and household duties. The comparative percentages among males and females involved in childcare and household duties are

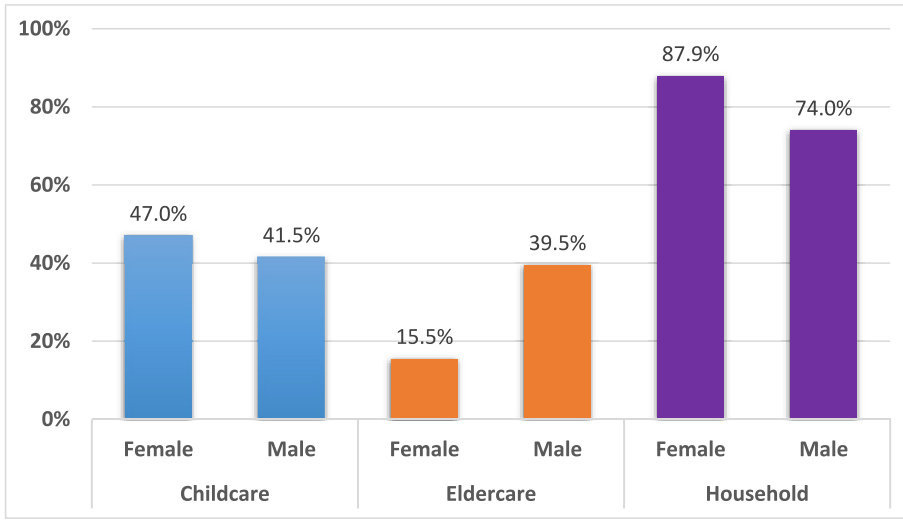

FIGURE 1 Percentage of female versus male involved in childcare, eldercare/disabled, household duties during the lockdown

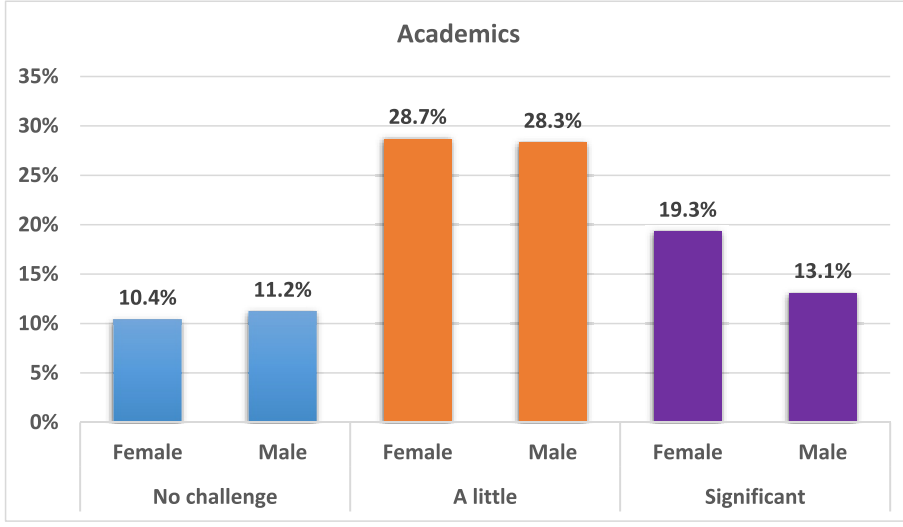

FIGURE 2 Gender-based challenges (or lack of) encountered by academics regarding online teaching

remarkable and laudable, showing an increased involvement of males in such activities compared to the past decades. Even more remarkable are the results reporting eldercare, where male involvement nearly doubles the one from women.

Figures 2 and 3 are representations of gender-based challenges (or lack of) encountered by academics and clinical scientists regarding online teaching and online research, respectively. The data show great similarities among male and female responders from both professional categories. Around 28% of participants encountered little challenge with online activities, while an average of 16.2% academics and 15.5% clinical scientists faced significant difficulties. Some of the main reasons reported by the survey participants (both male and female) are the following.

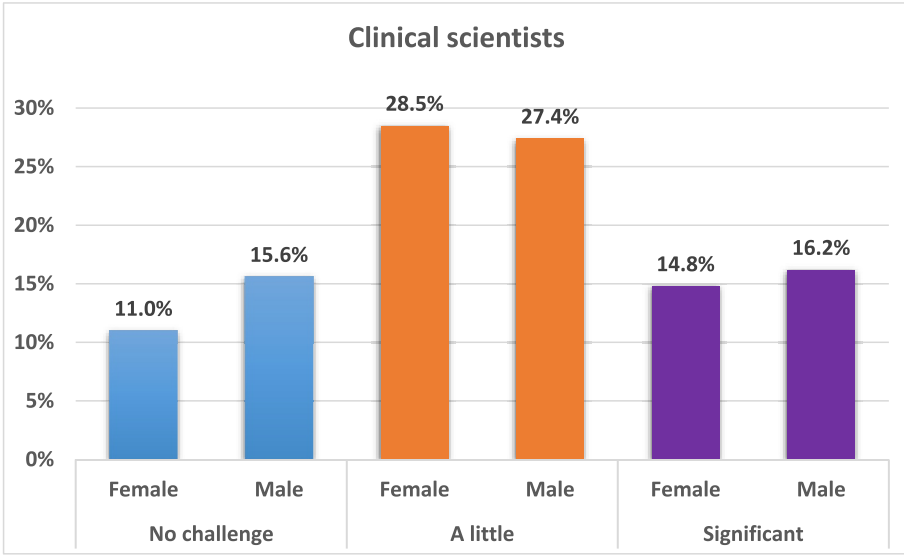

FIGURE 3 Gender-based challenges (or lack of) encountered by clinical scientists regarding online work/research

- Technical challenges:
  - Training (or lack of) for operating online teaching platforms.
  - Internet speed and connectivity; infrastructure connection.
  - Security and data protection.
  - Remote access to restricted hospital files and clinical data.
  - Lack of skills to conduct online activities (either from the student or the teacher).
  - Short time to learn new skills for online teaching.
- Communication/interpersonal challenges:
  - Gaining students' attention.
  - Assuring confidentiality, trust, and integrity during online assessment.
  - Maintaining student interaction (within student groups) and motivation.
  - Assessing students' understanding through body language.
  - Keeping up with students' progress.
  - Lack of interactivity and feedback from class.
  - Remote students faced limited Internet access, limited interaction with peers and teachers.
  - Communication (or lack of) between different professions within clinics.
- Logistical challenges:
  - Adaptation to new online platforms.
  - Reorganize/convert teaching materials to fit the online system.
  - Consider/design new evaluation methods suitable for online assessment.
  - Lack of access to research facilities.
  - Replace practical/lab activities with other tasks that can be conducted at home.
- Distraction from work:
  - Living together with small children often caused interruption/interference with online activities.
  - Various domestic tasks.
  - Keeping concentration for long time.

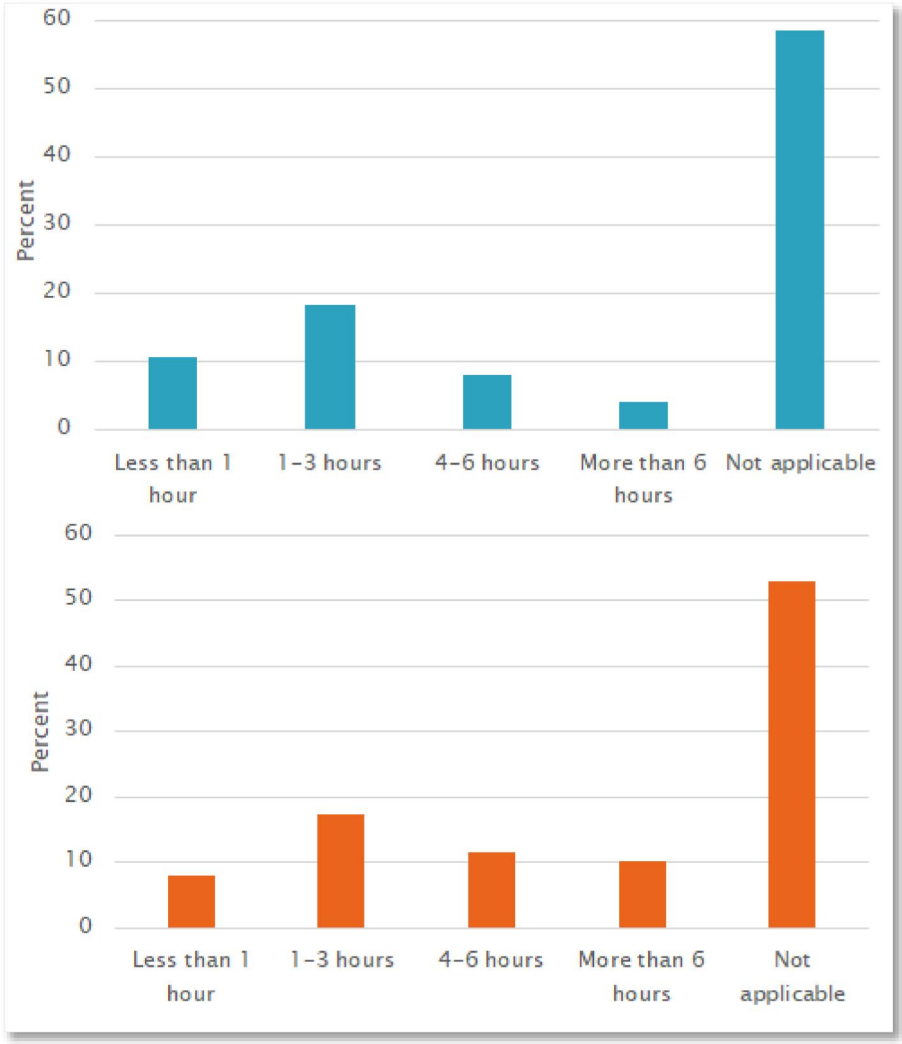

FIGURE 4 Gender-based distribution of answers to the question: While working from home during COVID-19 pandemic, what are the average daily hours spent on childcare and schooling? (Top: males; bottom: females)

Finally, Figure 4 shows the average daily hours spent on childcare and schooling for males and females (as discussed above).

4 | DISCUSSION

The WFH survey developed by our group was distributed worldwide to assess the main issues that biomedical engineers and medical physicists (academics and professionals) and other similar professionals have been facing when working from home during the pandemic. The aggregated data provided demographic and geographic information that was analyzed by gender. This allowed assessing the impact of the pandemic on the careers of women and men. We were pleasantly surprised by the response to our survey with 921 valid responses received.

Contrary to the expectations that women still carry the larger burden of childrearing and household duties, have lesser access to a home office, have had to adjust working hours more as compared to their male counterparts, our survey has identified that males are now more involved in family responsibilities and tasks than they were 20–30 years ago. This indicates a positive shift in our societies with changing masculine image and expectations: it is now more accepted for men to take part in household chores and upbringing of children. In addition, with more women now entering the work force and have professional careers, rather than being stay-at-home mothers, the result is a shift of traditional roles and both partners have to share, at least to some extent, their family responsibilities.

Despite the shift of traditional roles, the differences in how both genders have dealt with the working-from-home situation remain. In response to a question on the biggest challenges during the lockdown, male respondents reported: issues with buying daily necessities, disruption of routine, access to health care, keeping up with a massive increase in workload, loneliness and housework, not being able to work from home and help their spouses with childcare, to concentrate on work not household, social isolation, stress and others. On the other hand, women reported the following challenges: childcare, having to juggle their own work and home-based schooling, to manage work and children and household, lack of human touch, feeling unsafe to go out, blurring work and home boundaries, social isolation, not being able to see family. It is clear that the management of work and family duties affected women more than it did men.

There were no significant differences observed between the fractions of clinical and academic biomedical engineers and medical physicists regarding their perceived challenges created by working from home.

4.1 | Reliability and validity

While over 920 valid responses were received, based on the demographic data, 46% of responses have come from a Caucasian population, hence the results may more represent the experiences of this particular ethnicity. Similarly, the most responses were received from the United States, Australia, Canada, Singapore, and Taiwan—all high-income countries (see Appendices A and B). While, on one hand, this may present some bias on the reported results, this also simply reflects the fact that these professions are mostly present in high income and upper-middle-income countries—as they are linked to the operation of state-of-the-art medical equipment (such as linear accelerators, MRI or PET scanners, etc.) that is not readily available in low income countries. Additionally, all questions (apart from the consent-related questions) were not compulsory due to ethical requirements. Hence, the number of responses to each analyzed question varied, potentially affecting the statistics.

4.2 | Future work

In the next step of data analysis obtained from this survey, we will evaluate the qualitative data collected and will aim to identify potential regional trends (if any).

5 | CONCLUSIONS

While several articles have been published on various aspects of working from home during the pandemic, they did not address the gender differences in regard to time spent on childrearing and household duties, or even access to home office. This is the gap that has been addressed by our working-from-home survey. The response to the survey reflects not only globally representative data but also captures the challenges relevant to the working biomedical engineers, medical physicists, and other STEM-related fields. It is interesting to note that men participate in child care and household duties in a relatively high percentage; although this is fewer hours daily than for women, it is

definitely far more than can be found 2 and 3 decades ago. Future analysis will look at this last aspect for various regions in the world. It is evident that the burden of child care and household duties will have a negative impact on the careers of women if the burden is not similar for both sexes, unless policies of organizations that hire them can provide accommodation and compensation to minimize the negative impact on the professional status and career of men and women who work in STEM fields.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

AUTHOR CONTRIBUTIONS

The survey concept was initiated by Monique Frize and Eva Bezak. All authors contributed toward the survey development. Monique Frize organized ethics endorsement. Eva Bezak collected data. Monique Frize, Eva Bezak, Loredana G. Marcu, Magdalena Stoeva, and Lenka Lhotska conducted the main data analysis and prepared the first paper draft. Paper was reviewed and amended by Virginia Tsapaki, Sierin Lim, Ana Maria Marques da Silva, Eleni Kaldoudi, Fatimah Ibrahim, Gilda Barabino, and Peck Ha Tan.

DATA AVAILABLITY STATEMENT

Data available on request due to privacy/ethical restrictions: The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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APPENDIX A Distribution of responses based on the country of workplace

Country	No. of responses	Responses (%)	Country	No. of responses	Responses (%)
United States of America	126	13.68%	Bulgaria	3	0.33%
Singapore	113	12.27%	Chile	3	0.33%
Canada	98	10.64%	Hong Kong	3	0.33%
Australia	88	9.55%	Bangladesh	2	0.22%
Taiwan	79	8.58%	Egypt	2	0.22%
Malaysia	65	7.06%	Morocco	2	0.22%
Brazil	51	5.54%	Nepal	2	0.22%
Czech Republic	22	2.39%	Nicaragua	2	0.22%
Spain	21	2.28%	Switzerland	2	0.22%
United Kingdom	21	2.28%	Afghanistan	1	0.11%
Finland	17	1.85%	Albania	1	0.11%
Japan	13	1.41%	Azerbaijan	1	0.11%
Argentina	12	1.30%	Bhutan	1	0.11%
Germany	10	1.09%	Cameroon	1	0.11%
India	10	1.09%	Ecuador	1	0.11%
New Zealand	9	0.98%	El Salvador	1	0.11%
Ireland	8	0.87%	Estonia	1	0.11%
Italy	8	0.87%	Georgia	1	0.11%
Ghana	7	0.76%	Greece	1	0.11%
Mexico	7	0.76%	Guyana	1	0.11%
Portugal	7	0.76%	Haiti	1	0.11%
Thailand	7	0.76%	Israel	1	0.11%
China	6	0.65%	Jamaica	1	0.11%
France	6	0.65%	Lithuania	1	0.11%

APPENDIX A (Continued)

Country	No. of responses	Responses (%)	Country	No. of responses	Responses (%)
Belgium	5	0.54%	Mauritania	1	0.11%
Colombia	5	0.54%	Mauritius	1	0.11%
Costa Rica	5	0.54%	Mongolia	1	0.11%
Nigeria	5	0.54%	Pakistan	1	0.11%
Romania	5	0.54%	Paraguay	1	0.11%
Cuba	4	0.43%	Peru	1	0.11%
Denmark	4	0.43%	Qatar	1	0.11%
Netherlands	4	0.43%	Republic of Moldova	1	0.11%
Norway	4	0.43%	Slovenia	1	0.11%
Philippines	4	0.43%	Syrian Arab Republic	1	0.11%
Venezuela	4	0.43%	FYR of Macedonia	1	0.11%
Sweden	4	0.43%	Tunisia	1	0.11%
South Korea	4	0.43%	United Arab Emirates	1	0.11%
Austria	3	0.33%	Tanzania	1	0.11%

APPENDIX B Distribution of responses by the income classification of the country of workplace

Country	Responses (%)	Responses	Income	Country	Responses (%)	Responses	Income
United States of America	13.68%	126	H	Mexico	0.76%	7	UM
Singapore	12.27%	113	H	Thailand	0.76%	7	UM
Canada	10.64%	98	H	China	0.65%	6	UM
Australia	9.55%	88	H	Colombia	0.54%	5	UM
Taiwan	8.58%	79	H	Costa Rica	0.54%	5	UM
Czech Republic	2.39%	22	H	Cuba	0.43%	4	UM
Spain	2.28%	21	H	Venezuela	0.43%	4	UM
United Kingdom	2.28%	21	H	Bulgaria	0.33%	3	UM
Finland	1.85%	17	H	Albania	0.11%	1	UM
Japan	1.41%	13	H	Azerbaijan	0.11%	1	UM
Germany	1.09%	10	H	Ecuador	0.11%	1	UM
New Zealand	0.98%	9	H	Georgia	0.11%	1	UM
Ireland	0.87%	8	H	Guyana	0.11%	1	UM

(Continues)

APPENDIX B (Continued)

Country	Responses (%)	Responses	Income	Country	Responses (%)	Responses	Income
Italy	0.87%	8	H	Jamaica	0.11%	1	UM
Portugal	0.76%	7	H	Paraguay	0.11%	1	UM
France	0.65%	6	H	Peru	0.11%	1	UM
Belgium	0.54%	5	H	TFYR Macedonia	0.11%	1	UM
Romania	0.54%	5	H	India	1.09%	10	LM
Denmark	0.43%	4	H	Ghana	0.76%	7	LM
Netherlands	0.43%	4	H	Philippines	0.43%	4	LM
Norway	0.43%	4	H	Bangladesh	0.22%	2	LM
South Korea	0.43%	4	H	Egypt	0.22%	2	LM
Sweden	0.43%	4	H	Morocco	0.22%	2	LM
Austria	0.33%	3	H	Nepal	0.22%	2	LM
Chile	0.33%	3	H	Nicaragua	0.22%	2	LM
Hong Kong	0.33%	3	H	Bhutan	0.11%	1	LM
Switzerland	0.22%	2	H	Cameroon	0.11%	1	LM
Estonia	0.11%	1	H	El Salvador	0.11%	1	LM
Greece	0.11%	1	H	Mauritania	0.11%	1	LM
Israel	0.11%	1	H	Mongolia	0.11%	1	LM
Lithuania	0.11%	1	H	Pakistan	0.11%	1	LM
Mauritius	0.11%	1	H	Moldova	0.11%	1	LM
Qatar	0.11%	1	H	Tunisia	0.11%	1	LM
Slovenia	0.11%	1	H	United Republic of Tanzania	0.11%	1	LM
United Arab Emirates	0.11%	1	H	Nigeria	0.54%	1	L
Malaysia	7.06%	65	UM	Afghanistan	0.11%	1	L
Brazil	5.54%	51	UM	Haiti	0.11%	1	L
Argentina	1.30%	12	UM	Syrian Arab Republic	0.11%	1	L