Professional practice changes in radiotherapy physics during the COVID-19 pandemic

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A 39-question survey on changes in departmental and clinical practice and on the impact for the future was sent to the global MP community. A total of 433 responses were analysed by professional role and by country clustered on the daily infection numbers.

Results: The impact of COVID-19 was bigger in countries with high daily infection rate. The majority of MPs worked in alternation at home/on-site. Among practice changes, implementation and/or increased use of hypofractionation was the most common (47% of the respondents). Sixteen percent of respondents modified patient-specific quality assurance (QA), 21% reduced machine QA, and 25% moved machine QA to weekends/

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evenings. The perception of trust in leadership and team unity was reversed between management MPs (towards increased trust and unity) and clinical MPs (towards a decrease). Changes such as home-working and increased use of hypofractionation were welcomed. However, some MPs were concerned about pressure to keep negative changes (e.g. weekend work).

Conclusion: COVID-19 affected MPs through changes in practice and QA procedures but also in terms of trust in leadership and team unity. Some changes were welcomed but others caused worries for the future. This report forms the basis, from a medical physics perspective, to evaluate long-lasting changes within a multi-disciplinary setting.

1. Introduction

The outbreak of the Severe Acute Respiratory Syndrome CoronaVirus 2 (SARS-CoV-2) causing Coronavirus disease 2019 (COVID-19) is an extreme event with complex spread-dynamics [1]. The crisis has produced different infection rates and strain levels on the healthcare systems of different countries. Radiotherapy (RT) has been recognized as an essential non-elective treatment for many tumour entities [2,3]. Cancer patients are at increased risk of COVID-19-related complications [4]. Although RT services continued, important changes were implemented rapidly to enhance patient and staff protection against infection, including treatment delay or RT schedule alterations [2,3,5–12]. This also affected medical physicists (MPs), who are key healthcare professionals in sustaining safe, effective, and efficient RT under constraints of social distancing and national/regional pandemic-related guidelines [12].

In addition to legal requirements for MPs presence at the hospital, which may differ internationally, Whitaker et al. distinguished four types of tasks from a practical standpoint [14]. First, direct patient-facing tasks, such as brachytherapy, first fraction verification for complex treatments and in-vivo dosimetry represent a small but vital portion of the workload requiring MPs on-site during treatment hours. Second, some measurement-based quality assurance (QA) requires on-site presence but can be performed out of treatment hours. Third, treatment planning-related, quality management, and administrative tasks can often be done remotely. Fourth, project planning, education, training and research can often be performed remotely or potentially postponed for clinical staff.

Researchers that mostly have type-4 tasks were most likely to work from home while clinical MPs needed to work on-site and/or on shift [13–15]. Management MPs were involved in decision making and liaising between hospital administration and clinical staff [9]. Thus, MPs may have had widely diverse experiences during COVID-19 due to different roles and responsibilities.

Most RT service changes were aimed at limiting patient presence at the hospital (e.g. RT postponement when clinically supported, or hypofractionation) and to limit interaction between team-members (e.g. shift work) [2,5–10,16–18]. These were considered a “contingency standard of care” in an “early pandemic scenario” while more drastic resource shortages and patient triage were anticipated in a “second (later) pandemic scenario” [19,20]. MPs have less patient contact than radiation oncologists, radiation therapists (RTTs) and nurses. They perform many “behind the scenes” tasks, e.g. planning and patient-specific QA (PSQA), easily overlooked when establishing guidelines limiting patient contact. Whereas new publications are exploring the aftermath and lessons learned for future clinical practice [18,21–23] with potentially more patient-centric research and streamlined administrative and regulatory procedures [24], the impact for MPs is unclear.

This study presents a global survey of MPs experience during the first pandemic wave (March-June 2020). We aim to understand the different challenges faced by MPs in different roles and countries and the potential impact for future practice. Results were analysed for three country clusters based on daily number of infections in order to link the spread-dynamic and early/late pandemic scenarios to changes in medical physics practice. Results are also reported by professional role (management vs clinical MP) where relevant. From this study we can infer how to adapt to future crises, but also integrate potentially positive changes to keep for the future.

2. Materials and methods

A web-based questionnaire (Supplementary material A.I) was distributed to ESTRO’s physics members via e-mail (2500 recipients) and the broader medical physics community via social media. It contained 39 questions on demographics (questions 1–12), department organisation (13–20), changes in practice (21–31), morale and mental health (32–33) and expected future impacts (34–38), with an open text-box for further comment(s). Responses were collected anonymously from June 18 to September 24, 2020.

Of the 489 responses received, 50 with no information beyond the demographics and 6 from non-MP professionals were excluded. Results from the 433 respondents were analysed overall, as well as by professional group and country cluster, where relevant.

The largest professional groups were clinical MPs (N = 298, 69%) and head of medical physics/management (hereafter “management MP”). N = 110, 25%). Fifteen research/academic physicists (3%) and 10 with other or non-specified roles (2%) were only included in the overall analysis.

Countries were divided into clusters according to the daily number of infections [1], with cluster A (N = 222, 51%) containing Italy, Spain, UK, USA, that were generally most affected by the pandemic. Cluster B (N = 156, 36%) contained countries such as Belgium, the Netherlands, Switzerland. Cluster C (N = 45, 10%) contained countries with low daily case numbers, with most responses from Norway and New Zealand (see supplementary material A.II for details). Ten responses were not included in any cluster, but only in the overall analysis, because either country was not indicated or was not included in the analysis of [1]. The majority (68%) of responses came from Europe followed by US/Canada (16%), New Zealand and Australia (7%), Asia and Middle East (7%), Latin America and Africa (~1% each).

Demographics for clusters A and B were homogeneous (Supplementary Table A.III).

No response was mandatory and the number of responses per country were uneven. Therefore, no statistical analysis between subgroups could be performed.

3. Results

3.1. Organisation of the department

(Cluster) A-respondents were the most tested for COVID-19, and had the highest rates of positive/suspected patients and related treatment interruption (Table 1). The corresponding test rates and positive test rates were lower for B and lowest for C-respondents. A-respondents were more likely to be tested for COVID-19 after the first crisis peak, while B-respondents were more often tested before or at the crisis peak.

The proportion of respondents working at home or on location was similar across clusters (Supplementary Fig. 1). Only a third of clinical MPs worked fully on-site.

Thirty percent of A-respondents reported that there was no
contingency plan to handle the COVID-19 situation while for B and C-respondents this was 10% and 16%, respectively (Table 2).

Three-quarters of respondents indicated some form of team splitting, mostly implemented by alternating people at home or at work with daily, weekly, or less frequently, early/late shifts. For small departments with 1–2 treatment units, 30% of respondents indicated there was no team splitting. This number was 23%, 16% and 21% for departments with 3–6 units, 7–10 units or 10 or more units respectively. Some other arrangements, aimed at minimizing contact at work, included groups on-site without contact or people working at home whenever possible.

For just over half of the respondents, departments were not split into clean/at risk areas (Table 2). However, about a third of respondents were split into clean/at risk areas (Table 2). Yet 13 A-respondents and eight B-respondents reported not having contact could be avoided. Some reported having specialized equipment (visor, high filtration masks) for brachytherapy.

The percentage of physics staff staying away due to being infected was highest in cluster A and lowest in C (Table 2). The percentage staying away due to quarantine was higher than for infection, and cluster A had the highest rates. Other common reasons to stay away were risk factors or pregnancy (self or relative, 49 respondents), child-care (13), suspected infection/awaiting test results (8) or travel (self or

Table 1
Infection situation in the department by country cluster and overall.

| By cluster | A (N = 222) | B (N = 156) | C (N = 45) | Overall (N = 433) |
|------------|-------------|-------------|-------------|-------------------|
| Were you tested for COVID-19 (e.g. blood, nose/mouth swab)? (Q11) | | | | |
| No | 104 (47%) | 88 (56%) | 36 (80%) | 234 (54%) |
| Yes, at the start of the crisis | 11 (5%) | 24 (15%) | 4 (9%) | 40 (9%) |
| Yes, at the peak of the crisis | 29 (13%) | 27 (17%) | 3 (7%) | 62 (14%) |
| Yes, after the peak of the crisis | 78 (35%) | 17 (11%) | 2 (4%) | 97 (22%) |
| Was any patient COVID-positive (or suspected) treated in your department? (Q11) | | | | |
| Yes | 152 (68%) | 85 (54%) | 11 (24%) | 251 (58%) |
| No | 47 (21%) | 51 (33%) | 23 (51%) | 127 (29%) |
| I don’t know | 22 (10%) | 20 (13%) | 11 (24%) | 54 (12%) |
| No response | 1 (1%) | 0 (1%) | 0 (1%) | 1 (1%) |
| Did any patient have their treatment interrupted because of confirmed/suspected COVID-19 infection? (Q12) | | | | |
| Yes | 99 (45%) | 57 (37%) | 13 (29%) | 172 (40%) |
| No | 75 (34%) | 61 (39%) | 19 (42%) | 162 (37%) |
| I don’t know | 47 (21%) | 38 (24%) | 13 (29%) | 98 (23%) |
| No response | 1 (1%) | 0 (1%) | 0 (1%) | 1 (1%) |

Table 2
Organisation of the department by country cluster and overall.

| By cluster | A (N = 222) | B (N = 156) | C (N = 45) | Overall (N = 433) |
|------------|-------------|-------------|-------------|-------------------|
| How well prepared was the department for the COVID-19 emergency? (Q13) | | | | |
| Some contingency plan, but we had to develop the plan further as we went along | 132 (59%) | 93 (60%) | 21 (47%) | 253 (58%) |
| Well-developed contingency plan | 44 (20%) | 46 (29%) | 13 (29%) | 105 (24%) |
| No contingency plan | 44 (20%) | 15 (9%) | 7 (16%) | 67 (15%) |
| Other | 1 (2%) | 2 (1%) | 1 (2%) | 4 (1%) |
| Did you divide the team? (Q14/15) | | | | |
| Yes split but not alternate (one group at home) | 23 (10%) | 21 (13%) | 4 (9%) | 52 (12%) |
| Yes split and alternate between work/home | 117 (53%) | 72 (46%) | 34 (76%) | 227 (52%) |
| No, no split | 56 (25%) | 38 (24%) | 4 (9%) | 100 (23%) |
| Other (see text for description) | 26 (12%) | 24 (15%) | 3 (7%) | 53 (12%) |
| No response | 0 (1%) | 1 (1%) | 0 (1%) | 1 (1%) |
| Did you divide the department into clean/at risk areas? (Q16) | | | | |
| Yes | 79 (36%) | 55 (35%) | 12 (27%) | 148 (34%) |
| No | 130 (59%) | 85 (54%) | 27 (60%) | 249 (57%) |
| Other (see text for description) | 11 (5%) | 13 (8%) | 4 (9%) | 29 (7%) |
| No response | 2 (1%) | 3 (2%) | 2 (4%) | 7 (2%) |
| Did you have the means to work remotely in planning? (Q17) | | | | |
| No, we did not get remote connection | 30 (14%) | 45 (29%) | 13 (29%) | 92 (21%) |
| Yes, we got it as soon the emergency started | 48 (22%) | 21 (13%) | 6 (13%) | 76 (17%) |
| Yes, we already had it | 90 (41%) | 63 (40%) | 22 (49%) | 180 (41%) |
| Yes, we got it but not immediately | 43 (19%) | 16 (10%) | 4 (9%) | 63 (14%) |
| Other | 9 (4%) | 10 (6%) | 0 (1%) | 19 (4%) |
| No response | 2 (1%) | 1 (1%) | 0 (1%) | 3 (1%) |
| Was the physics personnel screened daily for COVID symptoms? (Q18) | | | | |
| Yes | 84 (38%) | 85 (54%) | 12 (27%) | 185 (43%) |
| No | 138 (62%) | 70 (45%) | 29 (64%) | 247 (57%) |
| No response | 0 (1%) | 1 (1%) | 4 (9%) | 1 (1%) |
| Which personal protective equipment was available from the hospital for MPs at the peak of the crisis? (Q19) | | | | |
| Gloves | 131 (59%) | 85 (54%) | 30 (67%) | 254 (58%) |
| FFPE/N95 mask | 44 (20%) | 38 (24%) | 6 (13%) | 92 (21%) |
| Surgical mask | 190 (86%) | 101 (65%) | 28 (52%) | 329 (76%) |
| Protective glasses | 4 (9%) | 59 (14%) | (continued on next page)

<sup>a</sup> Ten responses are not associated with any cluster (see supplementary material A.11).

<sup>b</sup> This question referred to the first peak of the crisis (March–June 2020).
Two respondents reported that staff remained at home because of pandemic-related anxiety or distress.

3.2. Changes in practice

This section is based on 411 responses. The most widely implemented change was increased use or implementation of hypofractionation (193 responses, 47%, Fig. 1). This was more prevalent in cluster A (54%) and in large-volume centres (4000+ patients/year, 70%). Decreased gating use and increased simultaneous integrated boost (SIB) use was reported by 11% of respondents. Overall, 156 (38%) respondents implemented no changes in techniques (15% for large-volume centres).

In addition, 16 respondents observed a reduction in RT and 11 mentioned postponing prostate RT with longer hormone treatment instead. Fifty-six (14%) respondents (37 from cluster A) observed a workload increase, including 13 where RT was given instead of surgery and/or chemotherapy. Six had more head and neck referrals; five had additional data collection or reporting; and four reported increased workloads due to initial replanning or additional QA for hypofractionated treatments.

PSQA and machine QA procedures were changed/reduced by 16% and 21% of respondents respectively (Table 3). For 25%, QA was moved to weekend or evenings to limit interactions. Others often did QA “whenever possible”.

Overall, 49% of respondents did not need changes to compensate for extra time for cleaning/sterilizing rooms after treating COVID-positive patients, while 17% and 18% extended working hours and reduced patient numbers, respectively (Table 3). Thirteen respondents indicated that no COVID-positive/suspected patients had been treated in their department. Twelve reported that the reduced patient numbers compensated for the extra cleaning time.

Most respondents reported that treatment unit technical support was available (Supplementary Table A.IV). Preventive maintenance was cancelled for 30% of A-respondents, 22% of B and 27% of C. Replacements of the high-dose rate/pulsed-dose rate afterloader sources were generally carried out as planned.

Some MPs participated in COVID-related research initiatives: 49 respondents reported that MPs helped design databases, 48 collected data (e.g. cone-beam CT), 15 participated in radiomics studies, eight investigated low-dose RT as COVID-19 treatment, four wrote papers on their experience and one investigated mask sterilization.

![Fig. 1. Changes in treatment technique (Q21) overall (red box), by country cluster (left of the dotted line) and by centre size in patients treated per year (right of the dotted line). Ten responses not associated to any cluster and 25 responses without an answer for the number of patients treated per year are only included in the “Overall” group. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)](image-url)
Table 3
Changes in QA practice and time required to sterilise the linac room by country cluster and overall.

| By cluster | A (N = 214) | B (N = 143) | C (N = 44) | Overall (N = 411) |
|------------|-------------|-------------|------------|------------------|
| Did you change patient specific QA? (Q22) | | | | |
| No, we continued the same way | 181 (85%) | 121 (85%) | 37 (84%) | 346 (84%) |
| Reduction of pre-treatment QA | 15 (7%) | 4 (3%) | 2 (5%) | 23 (6%) |
| Reduction or stopped in-vivo dosimetry (diodes) | 7 (3%) | 3 (2%) | 0 (0%) | 10 (2%) |
| Increase use of EPID or other online in-vivo QA | 7 (3%) | 5 (3%) | 1 (2%) | 15 (4%) |
| Increase use of remote automatic PSQA | 5 (2%) | 2 (1%) | 1 (2%) | 8 (2%) |
| Other | 13 (6%) | 8 (6%) | 3 (7%) | 24 (6%) |
| Did you change the tests for treatment unit QA? (Q23/24) | | | | |
| No, we did not change | 176 (82%) | 111 (78%) | 33 (75%) | 326 (79%) |
| Yes, we stopped yearly/quarterly tests | 12 (6%) | 6 (4%) | 4 (9%) | 23 (6%) |
| Yes, we reduced tests frequency | 14 (7%) | 12 (8%) | 4 (9%) | 32 (8%) |
| Yes, we reduced the number of tests | 14 (7%) | 6 (4%) | 0 (0%) | 22 (5%) |
| Did you change the time for treatment unit QA? (Q25) | | | | |
| We kept the same machine QA slots | 135 (68%) | 99 (69%) | 30 (68%) | 269 (65%) |
| We moved QA to a different slot | 59 (28%) | 30 (21%) | 10 (23%) | 103 (25%) |
| Other | 14 (7%) | 4 (3%) | 1 (2%) | 20 (5%) |
| No response | 6 (3%) | 10 (7%) | 3 (7%) | 19 (5%) |

To compensate for the extra time needed to sterilise the linac room, after treating a COVID patient, RT/MP services needed to (Q29): Extend working hours | 28 (13%) | 34 (24%) | 4 (9%) | 68 (17%) |
| Reduce the number of patients treated | 45 (21%) | 18 (13%) | 7 (16%) | 72 (18%) |
| No changes | 99 (46%) | 73 (51%) | 26 (59%) | 203 (49%) |
| Other (see text) | 42 (20%) | 15 (10%) | 5 (11%) | 62 (15%) |

Acronyms: EPID: electronic portal imaging device.
* 10 responses are not associated with any cluster (see supplementary material A.11).

3.3. Morale and mental health

This section is based on 410 responses. To keep the team united during the pandemic, 282 (69%) respondents used email, 199 (49%) texting groups, 108 (26%) voice-only teleconference, 195 (48%) video-conferencing, 143 (35%) communication and collaboration platforms, and 124 (30%) on-site face-to-face meetings.

Additionally, 20 respondents reported virtual social interactions. Fifteen respondents reported that staff had supported each other (as a personal initiative). Four wrote that the lack of support had been hard on them, while seven indicated there was no need for any support. Eight people mentioned increased flexibility in working time, six that there was some kind of support, and six mentioned psychological support available at various levels.

3.4. Future impact

This section is based on 406 responses. Over all professional groups, more respondents noted an increase, rather than a decrease, in trust between team members (Fig. 2). For management MPs, responses indicated an increased feeling of team unity and trust in leadership. However, for clinical MPs, the tendency was reversed.

Over 70% of respondents, over all professional groups, reported that working from home had become more acceptable and 48% reported that flexible working had become more acceptable. Forty percent of respondents reported the use of new online tools. Sixty-eight percent of respondents would like home-working to remain after the pandemic and a slightly lower number believes that is likely (Fig. 3). Regarding clinical practice, there is some interest in keeping more hypofractionation after the pandemic and a similar number said that is likely. Generally, wishes and likelihoods for changes was evaluated slightly higher by management MPs than by clinical MPs. Some respondents noted other things they would like to remain: paperless clinics (9), online meetings (6), flexible working (5) and more online conferences or exams (5). Few respondents (45 overall, 11%) hope that no changes will remain after the pandemic.

The majority of respondents (83%) were not concerned about pressure to keep changes made to cope with increased workload, but 48 (12%) had concerns (14% of management, 12% of clinical MPs). Among these, 21 mentioned pressure for out-of-hours work (week-end, evenings). Seven were concerned about increased workloads or less time/staff for the same amount of work.

Finally, other comments shared at the end of the survey generally indicated a willingness to learn and reflect on the changes necessitated by COVID-19. Some wrote that they were proud of their team and management and of how they had been well prepared. In contrast, others were disappointed in management and/or felt unheard. Unedited, anonymous comments are available in supplementary material A. IV.

4. Discussion

We report on the experience of 433 MPs from 40 countries worldwide during the early stage of the COVID-19 pandemic. Overall, they observed substantial changes in working situations and their institution’s clinical practice. Shift working with weekly alternation at-home/on-site with minimal contact and the use of PPE was frequently adopted to limit the infection risk for clinical MPs.

Countries were grouped in clusters based on COVID-19 data up to April 12, 2020 [1] while responses were collected between June-September 2020. The cluster-based analysis may be biased with certain countries or centres being over-represented. Moreover, because the situation is highly dynamic, this survey should be considered a snapshot in time. Different pandemic stages have been identified as “early pandemic scenario” aiming for contingency standard of care and “late pandemic scenario” anticipating more drastic resource shortages and patient triage [19,20]. A-countries had typically reached the latter stage early, while C-countries mostly remained in the early stage at the survey time and could learn from A-countries experience. This difference in burden on healthcare systems was reflected in the department infection situation and organisation (Tables 1 and 2). A-respondents had the highest numbers of infected staff or those staying away from the department and the most infected/suspected patients. They were also most tested for COVID-19 but typically after the first peak, likely due to shortage of tests early in the pandemic, e.g. as reported in Spain [9]. Conversely, B-respondents were more often tested at the crisis start or peak (Table 1). Access to PPE at the first crisis peak for A-respondents was similar to other clusters. However, thirteen A-respondents reported having no or insufficient hospital-provided PPE, consistent with reported PPE shortages [2,3], while some B-respondents reported not needing PPE because contact could be avoided. Having little patient contact, MPs might have had low priority for PPE access despite the risk of infection among colleagues.

There was little difference in change of practice between clusters (Fig. 1, Table 3). Nevertheless, the most common change,
implementation or increased use of hypofractionation (47% overall), was more predominant in cluster A (54%). The increase was markedly more common in centres with large patient numbers and it has been proposed extensively to reduce the patient presence in the hospital [12]. However, hypofractionation use is country-dependent [17,25] and for centres not yet applying it, implementation represents significant work, not easy to carry out under pressure [12]. Concerns around its level of evidence have also been raised which may have prevented wider implementation [12,20]. Despite its advantages, hypofractionation may involve increased MPs workload, from PSQA, first fraction verification, and initial replanning at implementation. Others reported that already planned hypofractionation implementation or paperless clinics, were accelerated by the pandemic.

Certain medical physics tasks can, in principle, be performed remotely (e.g. treatment planning) or on-site outside of treatment hours (e.g. machine QA) [14]. Indeed, remote planning access was already available before COVID-19 for about 40% of respondents. However, 14% of A-respondents and 29% of B and C-respondents had not yet got remote planning access during COVID-19. Khan et al. claim that the bulk of planning and plan checking could be performed remotely without quality loss [13], even if not supported by data. Although technically feasible, it has a cost and may be complicated by cyber-security and

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**Fig. 2.** Changes observed in working environment by professional group and overall. For a same colour, darker shades indicate an increase in unity/trust whereas a lighter shade indicates a decrease.

**Fig. 3.** Changes in practice for the future that respondents wish to keep (in dark shades) and how likely they are to remain (light shades). Results are presented overall in the red box and for management and clinical MPs on the left and right of the dotted line respectively. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
data-resource shortage are expected in the short term but should be based on international consensus. The challenge, looking ahead post-pandemic, is to optimize resource-use while maintaining treatment quality and safety and ensure an equitable workload and sustainable working conditions for all professionals. This task should include all stakeholders and further qualitative assessment via focus groups and/or new surveys to capture the evolution of clinical practice and COVID-19’s long-lasting effects. As previous reports considered the lessons learned from the oncologists [24] or RTTs [18] perspective, we hope that this report can constitute a basis to start this multi-disciplinary assessment from the medical physics perspective.

In conclusion, MPs have reported a large impact of COVID-19 on their work, depending on the number of daily infections in their country. This caused changes in practice such as increased use/implementation of hypofractionation and reorganisation of machine and patient-specific QA. The impact of these changes on team unity and trust in leadership has been perceived differently by management and clinical MPs. Although some changes were welcomed, there were also personal sacrifices. We hope this data will help reflect on the impact of this evolution on MPs for future crisis scenarios but also in regular practice.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.phro.2021.06.002.

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