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A BACPR survey evaluating the use of technology in cardiac rehabilitation during the COVID-19 pandemic: insights for future practice

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Abstract

Objective: To investigate whether exercise-based cardiac rehabilitation services continued during the COVID-19 pandemic, and investigate how technology has been used to deliver home-based cardiac rehabilitation.

Design: A mixed methods survey, including questions about exercise-based cardiac rehabilitation service provision, programme diversity, patient complexity, technology use, barriers to using technology, and safety.

Setting: International survey of exercise-based cardiac rehabilitation programmes

Participants: Healthcare professionals working in UK, and international, exercise-based cardiac rehabilitation programmes.

Main outcome measures: The proportion of programmes that continued providing exercise-based cardiac rehabilitation, and which technologies had been used to deliver home-based cardiac rehabilitation.

Results: Three-hundred and thirty eligible responses were received; 89.7% were from the UK. Approximately half (49.3%) of respondents reported that CR programmes were suspended due to COVID-19. Of programmes that continued; 22.4% used technology before the COVID-19 pandemic. Programmes typically started using technology within 19 days of COVID-19 becoming a pandemic. 48.8% did not provide CR to high-risk patients, telephone was most commonly used to deliver CR, and some centres used sophisticated technology such as teleconferencing.

Conclusions: The rapid adoption of technology into standard practice is promising and may improve accessibility, or participation, in exercise-based CR beyond COVID-19. However, the exclusion of certain patient groups and programme suspension, could worsen clinical symptoms and wellbeing, and increase hospital admissions. Refinement of current practices, with a focus on improving

inclusivity and addressing safety concerns around exercise support to high-risk patients, may be needed.

Abstract: 236 Words

Key words: Cardiac rehabilitation, COVID-19, Telehealth, Exercise training,

Article Summary

Strengths and limitations of this study

- This is the first international reporting on the effect that COVID-19 restrictions have had on exercise-based cardiac rehabilitation.
- We report data from *n*=330 cardiac rehabilitation programmes around the world, although the majority of data were from the United Kingdom.
- Our mixed methods survey enabled us to investigate how technology has been used to deliver exercise-based cardiac rehabilitation, as well the barriers to using technology.
- Respondents were only able to complete the survey once, but we could have received more than one response from professionals working in a single cardiac rehabilitation programme.
- Our data could be used to inform future research agendas, international healthcare policy, and local healthcare decision making.

Financial support

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Competing interests

None declared

Introduction

Cardiac rehabilitation (CR) is a comprehensive programme of secondary prevention interventions for patients with heart disease, encompassing support for psychosocial health, medical risk management and cardiovascular risk factor modification, including and exercise training [1]. Exercise-based CR reduces cardiovascular deaths and recurrent myocardial infarction within 10 years, hospital admissions within 2 years, and improves health-related quality of life [2-5]. Despite these benefits, only 49% (n=141,648) of eligible United Kingdom (UK) patients enrolled on to a CR programme between 2012 and 2015 [6]. Increasing uptake to 65% could lead to 21,000 fewer hospital admissions and 8,500 fewer deaths over 10 years [7]. In response, NHS England set an ambitious target to increase CR uptake to 85% by 2029 [8].

COVID-19 is spread by a highly contagious virus. As of September 2020, it has infected 26,121,999 and has killed 864,618 people worldwide [9]. The rapid spread of COVID-19 infections resulted in governments imposing restrictions on face-to-face human contact [10]. Numerous 'non-essential' healthcare services were suspended and patient attendance to continuing services has decreased due to fear of contracting COVID-19 [11, 12]. The COVID-19 pandemic may therefore undermine efforts to increase uptake to exercise-based CR.

Before COVID-19, expanding the availability of home-based programmes was recommended to increase participation in exercise-based CR [13]. This is partly due to a lack of capacity within existing face-to-face services [14]. Yet, in 2019, 8.8% of UK CR patients participated in home-based programmes [15]. The recent suspension of face-to-face healthcare services may have led to programmes rapidly adopting home-based, technology facilitated services. Data from urgent and non-urgent care centres in the United States of America (USA) reported that teleconferencing consultations increased from 82 on March 4th 2020, to 1336 on 19th March 2020 [16]. If a similar rate of technology adoption occurred in CR, this could have helped to maintain patient participation. These methods could also be adopted in to future standard practice to increase accessibility and subsequent uptake onto CR programmes.

The aim of this mixed-methods survey, conducted in collaboration with the British Association for Cardiovascular Prevention and Rehabilitation (BACPR), was to investigate whether exercise-based CR services continued during the COVID-19 pandemic. We also evaluated whether technology was used to deliver exercise-based CR, and the professional experiences of this technology, during the COVID-19 pandemic.

Materials and Methods

Survey development

The methods and results are reported in conjunction with the Checklist for Reporting Results of Internet E-surveys (CHERRIES; Appendix 1) [17]. This voluntary, cross-sectional, international, open survey, targeted at a convenience sample of healthcare professionals in exercise-based CR, was developed by SN and AFO. The broad topic of questions, relating to the COVID-19 pandemic, were:

1. If and how CR services were provided.
2. The demographics and medical complexity of patients accessing CR services.
3. How technology was used to undertake patient assessments and deliver the exercise component of CR.
4. The barriers encountered when using technology to deliver the exercise component of CR.

The survey was reviewed by the members of the BACPR elected Council prior to ethical approval, and amended accordingly. The BACPR council includes physicians, nurses, physiotherapists, exercise physiologists, exercise instructors, psychologists, dietitians, and occupational therapists. The resulting 35-item questionnaire was uploaded to the Qualtrics^{XM} online survey platform (Provo, Utah, USA). Qualtrics has ISO/IEC 27001 security certification. The automated database was password protected and stored on secure Qualtrics and Sheffield Hallam University servers. The survey was presented

across 21 pages, including background information and consent. There were 22 tick box items (19 mandatory), seven mandatory numerical responses, three non-mandatory sliding bar responses, two non-mandatory free-text responses, and one mandatory date entry response. Four questions also permitted free-text responses under the option 'other'. Response validation was used on all questions, where appropriate. Survey progress was displayed on each page. Participants did not have a completeness check/review option at the end of the survey. Participants were only able to visit the website once from the same IP address, and they had seven days to complete the survey once started. The functionality of the survey was tested by SN, AOD, SD, SH, and AC. The final version of the online survey (Appendix 2), was given institutional ethical approval by Sheffield Hallam University (ID: ER24303491), on the 29th May 2020. All participants provided informed consent, and all study procedures were carried out following the rules of the Declaration of Helsinki of 1975 (https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/), revised in 2013.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Survey dissemination

On 2nd June 2020, a recruitment e-mail was sent to BACPR members; 746 healthcare professionals and academics working in CR. This was repeated on June 25th 2020. The survey was also promoted on social media platforms (Appendix 3). A link to the survey *was not* posted on any website. The survey closed at 12pm on 31st July 2020. There were no incentives offered for participation.

Quantitative data analysis

Categorical data are reported as the number of responses, expressed as a percentage (%) of the respondents to each question. Continuous data are reported as median, with minimum and maximum values. Responses were reported for the full cohort, and by the Phase of CR that the respondents worked in. Phase I was defined as the inpatient stage, Phase II as the early discharge phase, Phase III as a clinically supervised outpatient programme, and Phase IV as long-term physical activity maintenance. Tests of statistical significance were not conducted.

Qualitative Data analysis

Free text answers were exported into NVivo 11 software for thematic analysis. Answers were coded inductively. The resulting coding framework was then reviewed to identify patterns and themes in the data. Similar codes were grouped to form lower order themes, which were then grouped into higher order themes. Each theme was given a descriptive explanation with illustrative quotes.

Results

Responses

Four-hundred and seven visits to the survey site were recorded. Seventy-seven (18.9%) did not progress past the study information and consent page (81.1% participation rate). Three-hundred and thirty responses were analysed, 296 (89.7%) were from the UK. The remaining responses were from Japan (*n*=8; 2.4%), Australia (*n*=4*;* 1.2%), the USA (*n*=4*;* 1.2%), Republic of Ireland (*n*=4*;* 1.2%), Gibralter (*n*=2*;* 0.6%), India (*n*=2*;* 0.6%), South Africa (*n*=2*;* 0.6%), Spain (*n*=2*;* 0.6%), the Bailiwick of Guernsey (*n*=1*;* 0.3%), Canada (*n*=1*;* 0.3%), the Isle of Man (*n*=1*;* 0.3%), and Kuwait *n*=1*;* (0.3%).

Service provision during COVID-19

At the time of responding, 163 (49.3%) CR programmes had been suspended due to COVID-19. The proportion of UK (*n=147;* 49.7%) and non-UK (*n*=16; 47.1%) services that had been suspended were

similar. Phase IV programmes were most likely to have suspended all activity (*n*=89; 72.4%). The remaining questions in the survey were applicable to 167 respondents (Table 1).

Following COVID-19 restrictions, 32 (19.9%) programmes reported that the same volume of patients were choosing to access their service. Most programmes (80.1%) reported that either fewer patients, or no patients were choosing to access their service. Programmes believed that patients enrolling in CR were either as demographically as diverse', or more diverse, than normal (*n*=129; 85.4%). UK CR programmes also estimated that 90.4% (0.0 to 100.0%) of patients seen in the last seven days were 'White British'. Most CR programmes (92.5%) reported that the age of participants was similar to normal, with 70% (0.0 to 100.0%) of patients enrolling in CR >65 years of age. Programmes also reported that the sex of patients participating in CR was proportionally similar to normal. Female participation in CR was estimated at 30% (0.0 to 80%).

Technology adoption

Figure 1 shows the increase in adoption of technology over time. The earliest date that a programme reported used technology was the 10th January 2010. The latest was the 20th June 2020. Twenty-eight programmes (22.4%) used technology to deliver exercise-based CR before COVID-19 was declared a pandemic by the World Health Organisation (WHO) [18]. The median date of technology adoption was 30th March 2020. There were notable increases in technology adoption, the first coincided with the release of the NHS long-term plan [8]. The second, more rapid increase, coincides with COVID-19 pandemic [18].

Technology use in patient assessment

The most commonly used technology was telephone (*n*=113; 85.0%). 23.1% (*n*=32) of programmes reported that they were not assessing or estimating functional capacity. Practitioners mostly relied on

patient self-reported fitness to estimate functional capacity (*n*=92; 69.2%). Some programmes estimated functional capacity by using a questionnaire (26.3%, *n*=35), or the patient's own physical activity tracker (21.1%, *n*=28). One Phase I (16.7%), two phase II (14.3%), and four Phase IV CR programmes (13.8%) remotely supervised exercise testing (Figure 2).

Table 1 – Provision of cardiac rehabilitation services during the COVID-19 pandemic, displayed as number (%)

	All	Phase I	Phase II	Phase III	Phase IV
Service status	(*n*=330)	(*n=14)*	(*n*=29)	(*n*=164)	(*n*=123)
Services able to see as many patients as usual	44 (13.3)	2 (14.3)	6 (20.7)	30 (18.3)	6 (4.9)
Service able to see fewer patients	123 (37.3)	6 (42.9)	12 (41.4)	77 (47.0)	28 (22.8)
Service suspended (%)	163 (49.4)	7 (42.9)	11 (37.9)	57 (34.8)	89 (72.4)
Patients accessing cardiac rehabilitation	(*n*=161)	(*n=8)*	(*n*=17)	(*n*=102)	(*n*=34)
No patients are accessing the service	18 (11.2)	2 (25.0)	3 (17.6)	9 (8.8)	4 (11.8)
Fewer patients are accessing the service	111 (68.9)	5 (62.5)	13 (76.5)	65 (63.7)	28 (82.4)
Same number of patients are accessing the service	32 (19.9)	1 (12.5)	1 (5.9)	28 (27.5)	2 (5.9)
Diversity of cardiac rehabilitation	(*n*=151)	(*n=7)*	(*n*=16)	(*n*=95)	(*n*=33)
Patient population is less diverse than before COVID-19	22 (14.6)	3 (42.9)	1 (6.25)	13 (13.7)	5 (15.2)
Patient population is as diverse as it was before COVID-19	122 (80.8)	4 (57.1)	15 (93.8)	78 (82.1)	25 (75.8)
Patient population is more diverse than before COVID-19	7 (4.6)	0 (0.0)	0 (0.0)	4 (4.2)	3 (9.1)
Patient population is younger than before COVID-19	6 (4.1)	0 (0.0)	2 (13.3)	2 (2.2)	2 (6.3)
Patient population is similar to what is was before COVID-19	135 (92.5)	5 (71.4)	12 (80.0)	89 (96.7)	29 (90.6)
Patient population is older than before COVID-19	5 (3.4)	2 (28.6)	1 (6.7)	1 (1.1)	1 (3.1)
Estimated percentage of patients in the last 7 days that were >65 years?	70.0 (0.0 to 100.0)	75.0 (60.0 to 85.0)	67.0 (38.0 to 100.0)	64.5 (0.0 to 100.0)	80.0 (0.0 to 1000.0)
Proportion of female participation is smaller	11 (0.8)	1 (16.7)	0 (0.0)	8 (9.4)	2 (6.9)
Proportion of female participation is the same	113 (83.7)	4 (66.7)	14 (93.3)	69 (81.2)	26 (89.7)
Proportion of female participation is larger	11 (0.8)	1 (16.7)	1 (6.7)	8 (9.4)	1 (3.4)
Proportion of male participation is smaller	6 (4.4)	1 (16.7)	1 (6.7)	2 (2.4)	2 (7.0)
Proportion of male participation is the same	123 (91.1)	4 (66.7)	14 (93.3)	79 (92.9)	26 (89.7)
Proportion of male participation is larger	6 (4.4)	1 (16.7)	0 (0.0)	4 (4.7)	1 (3.4)
Estimated percentage of patients in the last 7 days were female?	30.0 (0.0 to 80.0)	40.0 (10.0 to 70.0)	30.0 (1.0 to 57.0)	30.0 (0.0 to 80.0)	40.0 (1.0 to 73.0)

Technology use in physical activity and exercise prescription

Most services were able to provide physical activity advice (*n*=102; 82.9%). Seventy-two (58.5%) programmes (*n*=72) also offered structured exercise training programmes. Telephone remained the most commonly used technology to facilitate the physical activity or exercise component of CR (*n*=86, 64.7%). Pre-recorded online videos (*n*=69; 51.9%) were also widely used, particularly among Phase III programmes (*n*=54; 64.3%; Figure 3). Most CR services were able to provide physical activity or structured exercise training to patients at low (*n*=117; 95.1%) and moderate risk (*n*=109; 88.6%) of exercise-induced cardiac events. Half (51.2%; *n*=63) were able to offer services to patients at high-risk of exercise-induced cardiac events. Three (2.8%) programmes reported one adverse event resulting in minor injury whilst using technology to deliver the exercise component of CR (three events in total). There were no reports of life changing injury, or death.

Barriers to using technology

Respondents were asked to state *any* barriers that they encountered when using technology. Only two (1.9%) programmes reported 'no barriers'. Most (n=93; 86.9%) encountered a "lack of patient confidence" with technology (Table 2). Qualitative analysis of the barriers to using technology fell into two categories; logistical and organisational barriers, and patient-related barriers. Logistical and organisational barriers were largely a result of healthcare organisations being unprepared, and not familiar with using online healthcare delivery. Onerous governance processes or delayed access to the necessary IT equipment were also described. Patient-related barriers were associated with communication (either language or understanding), and concerns that patients were either over-reporting their activity or not following advice provided.

Practitioner experiences

Qualitative analysis of free text answers to the final question allowing "Any other comments" resulted in the identification of three higher order themes; i) impact on patient experience; ii) challenges for staff and iii) implications for future delivery.

i) Impact on patient experience

Survey respondents varied in their views about the impact on patient engagement and experience. Technology was acknowledged as a valuable means of connecting patients with CR staff, but a small number of respondents also highlighted that it was harder to establish a rapport this way. One participant reported a decline in patients' fitness outcomes whilst another claimed that patients exercised harder at home without peers to distract them. More commonly, participants reported that regardless of the perceived benefits of remote delivery, it was difficult to replicate the social benefits associated with group exercise delivery:

> *"The lack of contact with other patients means the patients miss out on the social and emotional support from each other."*

Table 2 –Barriers to using technology in exercise-based cardiac rehabilitation displayed as number (%)

Barriers to using technology	All (*n*=107)	Phase I (*n=6)*	Phase II (*n*=9)	Phase III (*n*=68)	Phase IV (*n*=24)
Lack of patient confidence	93 (86.9)	2 (33.3)	8 (88.9)	60 (88.2)	23 (95.8)
Patients do not have access to computers/tablets/smart phone	86 (80.4)	2 (33.3)	4 (44.4)	61 (89.7)	19 (79.2)
Patients do not have an internet connection	73 (68.2)	2 (33.3)	6 (66.7)	48 (70.6)	17 (70.8)
Patients lack of interest in receiving services using technology	65 (60.7)	1 (16.7)	5 (55.6)	44 (64.7)	15 (62.5)
Professionals are concerned about patient safety	43 (40.2)	0 (0.0)	3 (33.3)	34 (50.0)	6 (25.0)
Patients are concerned about safety	32 (29.9)	2 (33.3)	3 (33.3)	21 (30.9)	6 (25.0)
Internet security and patient confidentiality concerns	27 (25.2)	1 (16.7)	4 (44.4)	18 (25)	4 (16.7)
Professionals not confident delivering service using technology	24 (22.4)	0 (0.0)	2 (22.2)	19 (27.9)	3 (12.5)
Trust/Health Board do not support the delivery of health services using technology	16 (15.0)	1 (16.7)	0 (0.0)	14 (20.6)	1 (4.2)
No barriers	2 (1.9)	1 (11.1)	0 (0.0)	1 (1.5)	0 (0.0)

ii) Challenges for professionals

Survey participants cited a range of challenges to adoption of technology, including the limitations of existing platforms, such as smart device applications for CR. These were described as lacking patient-centred or motivational content and time-consuming to use. Participants reported further difficulties associated with COVID-19 related staff redeployment or illness, and reiterated barriers such as lack of access to technology and organisational delays caused by IT and governance restrictions.

A large number of comments described concerns relating to practitioners' inability to observe patients, limiting safe and accurate assessment of functional capacity. This had resulted in a more cautious approach, with respondents reporting that they prescribed only gentle or low-level exercise:

> *"Our main concern has been the difficulty of not being able to complete functional capacity assessments, we have therefore recommended patients exercise at a lower level than we normally would."*

iii) Implications for future delivery

Many respondents reported optimism about continuing to incorporate technology in future CR delivery. Nevertheless, it was generally recognised that delivery should be flexible. Exercise programmes should be tailored to individual needs and risk levels and patients should be provided with a range of options for engaging with CR, including both face-to-face contact with CR staff and online/home-based exercise.

Several comments indicated opportunities for improvement in the technology available, with one participant suggesting that current formats were driven by NACR audit data requirements as opposed to patient needs. Another respondent called for further research to inform more confident remote exercise prescription:

"Still feel face to face assessment is superior for more frail patients …and for higher risk patients… Nevertheless, I am gaining more confidence in remote assessment, and would be reassured further by some research to demonstrate its safety and efficacy. I already know remote delivery has been shown to be safe and effective, but as far as I am aware this has been evidenced only when prescribed from face to face assessment."

Quantitatively, 94 (88.7%) programmes believed that technology should be available for patients in the future.

Discussion

To our knowledge, this is the first study to quantitatively document the effect that restrictions, imposed due to COVID-19, had on exercise-based CR programmes. We found that nearly half of all programmes had been suspended and that most centres reported a reduction in patient engagement with services during the COVID-19 pandemic. Practitioners reported that the age and sex of patients attending CR was similar to before the COVID-19 pandemic. Technology was rapidly adopted to deliver CR, with less sophisticated technology, such as the telephone, being most widely used. Higher risk patients were less likely to be offered remote CR using technology. Nearly all centres reported barriers to using technology to deliver CR. Finally, despite an openness to adopting technology by practitioners, there were concerns surrounding availability of, and confidence in using technology. Qualitatively, patient assessment, less opportunity for socialisation, and safety were highlighted.

Service provision

COVID-19 has resulted in many non-essential healthcare services being suspended. We have shown that this was true for half of exercise-based CR services. In 2019, 89,573 patients accessed exercise-

based CR in the UK [15], therefore a high proportion of cardiac patients may have been negatively affected by this widespread service disruption. Given that exercise-based CR improves quality of life [4, 19] and reduces hospital admissions [3], suspension of services is likely to result in worsening clinical symptoms, wellbeing, and increased hospital admissions long-term. This may place an increased burden on healthcare services in the coming months. Nevertheless, there was an increase in the use of technology in CR shortly after COVID-19 was declared a Pandemic by the WHO [18]. Comparing long-term patient outcomes from programmes that continued service provision with programmes that were unable to continue will help to determine the effectiveness of these changes.

Technology adoption and barriers

Recent editorials and reviews have suggested that COVID-19 could be a catalyst for large-scale changes in the way that CR is delivered [20, 21]. We found that most services started using technology to deliver home-based exercise-based CR within three weeks of COVID-19 being declared a pandemic by the WHO [18], only three services were providing face-to-face services. This suggests that the capacity of CR services to provide home-based rehabilitation programmes has rapidly increased. If maintained, subject to robust evidence, the potential for increased accessibility, could positively influence participation in CR when face-to-face service have resumed.

Traditional modes of communication such as telephone were most commonly used. Surprisingly few services used tele-conferencing, smart device applications and web-based systems. Healthcare professionals cited that patients often lacked confidence using equipment and/or that patients did not have the required equipment for technology use. The number and sociodemographic profile of patients for whom this was a genuine barrier is unclear. Others have reported that age may be a factor, with people aged 22-44 years most likely use tele-conferencing facilities [16], and people over 65 years being less likely to have a smart phone [22]. This could warrant further investigation to address inequalities in the accessibility of technology-based provision of CR. Meanwhile, professionals'

concern for patient safety (40.2%) and internet security (25.2%) were also likely to contribute to the low uptake of novel technology. Healthcare organisations being underprepared for the adoption of new technology may also play a role, although this was less frequently reported in quantitative analysis. 'Top-down' endorsement of technology by health Trusts, Health Boards or healthcare providers may give healthcare professionals confidence in using technology.

Participation

Participation in CR continued despite COVID-19 restrictions. However, programmes were able to offer services to fewer patients and update was reduced. Furthermore, UK programmes reported that ~90% of participants were 'White British', which is proportionately higher than recently indicated (79%) in the 2019 NACR report [15]. Future research should investigate the direct impact of COVID-19 on minority group participation in exercise-based CR, and explore how to increase their participation when it is delivered using technology. Encouragingly, programmes reported that similar proportions of males and females, and people over the age of 65 years, engaged with CR compared to pre-COVID-19 participation.

Data from our survey showed that 41.5% of programmes were unable to provide exercise-based CR to patients at high-risk of exercise-induced cardiac events. CR should be available to all eligible patients, irrespectively of risk [1]. The development and refinement of future technology-based interventions should be inclusive of all risk levels. Qualitative comments highlighted concerns about using technology to remotely deliver exercise-based CR for frail patients. Safety concerns were also a common feature in our quantitative analysis (Table 2). The wide use of 'offline' delivery modes such as telephone and pre-recorded videos identified in our survey limits the capacity to evaluate physiological information during exercise and the scope for practitioners to tailor advice to the individual. It may be perceived as unsafe for patients at high-risk of exercise-induced event, but not

for lower risk patients. Overcoming these concerns, through robust evidence, may be an important step in negating future health inequalities.

Limitations

Most respondents were from the UK, which may limit generalisability of the findings to international programmes. Individual practitioners rather than centres were targeted to respond. Therefore, the risk of bias could have been increased by multiple practitioners from the same centre completing the survey. The sample size should limit interpretation bias.

Conclusions

Nearly half of all CR programmes have been suspended during COVID-19 restrictions. Technology was rapidly adopted by CR services which may increase participation beyond COVID-19. However, higher risk patients may be disadvantaged by technology use, whilst people in the UK who are 'White British' may be most likely to benefit for it. Our findings indicate a role for technology in future CR delivery. There is a need for innovation in patient-centred, interactive technological resources that also foster confidence amongst practitioners. Future research needs to investigate the longer-term adoption of technology in CR following COVID-19, and its effects on participation, patient experience and safety.

Author Statement

Conceptualization: Simon Nichols; **Methodology:** Simon Nichols, Alasdair O'Doherty, Helen Susan Dawkes, Aynsley Cowie, Sally Hinton; **Formal Analysis:** Simon Nichols, Alasdair O'Doherty, Helen Humphreys; **Investigation:** Simon Nichols, Alasdair O'Doherty, Helen Susan Dawkes, Aynsley Cowie, Sally Hinton, Peter Brubaker, Tom Butler; **Data curation:** Simon Nichols, Helen Humphreys; **Writing-Original draft preparation:** Simon Nichols; **Writing - Review & Editing:** Simon Nichols, Alasdair O'Doherty, Helen Susan Dawkes, Aynsley Cowie, Sally Hinton, Peter Brubaker, Tom Butler; **Visualization:** Simon Nichols; **Supervision:** Simon Nichols; **Project Administration:** Simon Nichols

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Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Data sharing

Data will be available, on reasonable request, 18 months after publication of the manuscript. Data can be requested by contacting the corresponding author, or by contacting library-research-support@shu.ac.uk.

Figure 1 – Data showing the use of technology to deliver exercise-based cardiac rehabilitation between January 2010 and June 2020. Black bars indicate how many programmes started using their chosen technology, on a given date. The grey area shows the cumulative number of cardiac rehabilitation programmes using technology.

Figure 2 – Types of technology used to undertake baseline assessments. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

Figure 3 – Types of technology used to deliver the exercise component of cardiac rehabilitation. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

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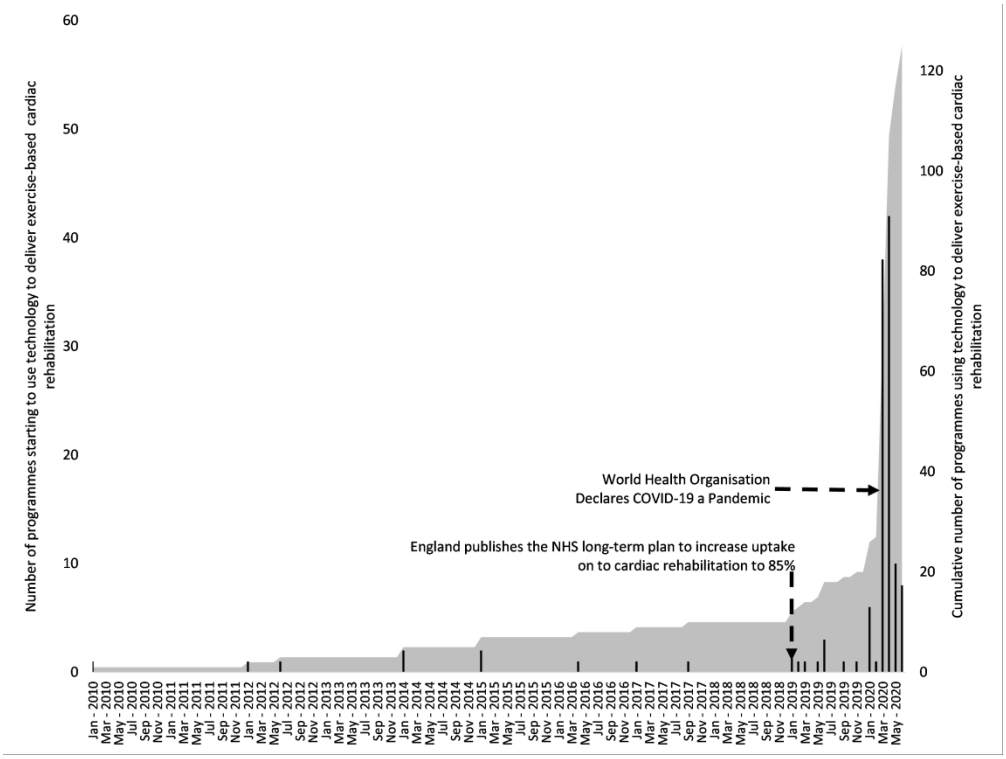


Figure 1 – Data showing the use of technology to deliver exercise-based cardiac rehabilitation between January 2010 and June 2020. Black bars indicate how many programmes started using their chosen technology, on a given date. The grey area shows the cumulative number of cardiac rehabilitation programmes using technology.

250x188mm (300 x 300 DPI)

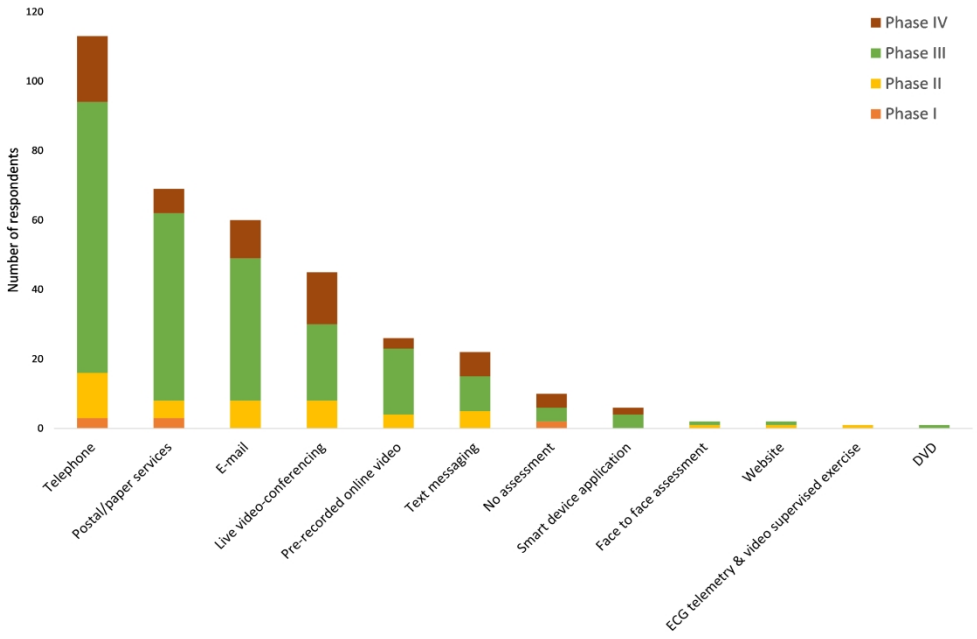


Figure 2 – Types of technology used to undertake baseline assessments. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

272x175mm (300 x 300 DPI)

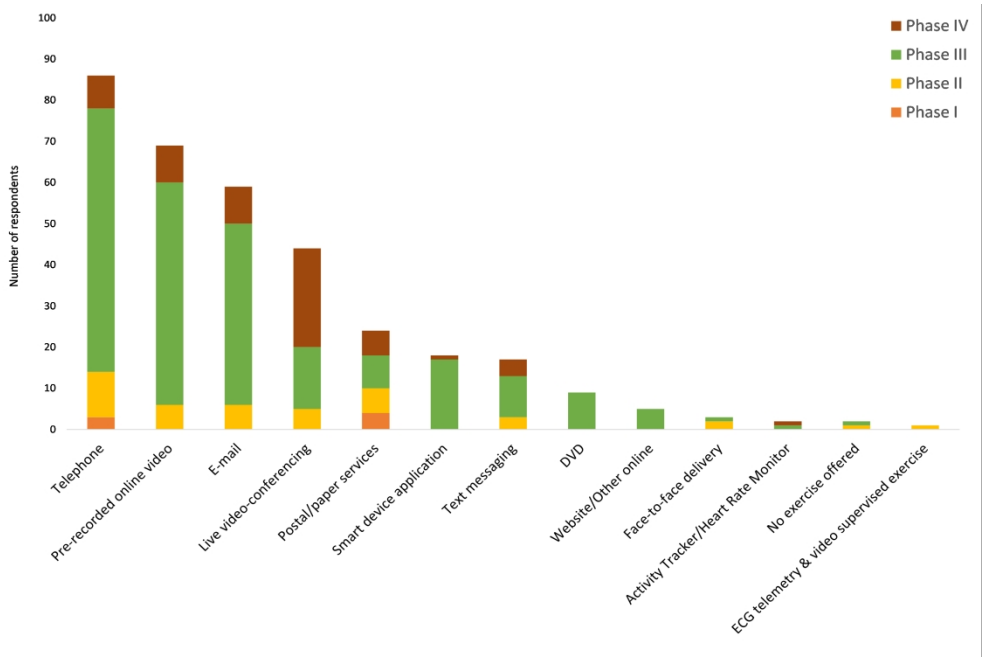


Figure 3 – Types of technology used to deliver the exercise component of cardiac rehabilitation. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

270x176mm (300 x 300 DPI)

Appendix 1 - Checklist for Reporting Results of Internet E-Surveys (CHERRIES)

Checklist Item	***Explanation***	***Page Number***
Describe survey design	Describe target population, sample frame. Is the sample a convenience sample? (In "open" surveys this is most likely.)	5
IRB approval	Mention whether the study has been approved by an IRB.	6
Informed consent	Describe the informed consent process. Where were the participants told the length of time of the survey, which data were stored and where and for how long, who the investigator was, and the purpose of the study?	Appendix 2
Data protection	If any personal information was collected or stored, describe what mechanisms were used to protect unauthorized access.	5
Development and testing	State how the survey was developed, including whether the usability and technical functionality of the electronic questionnaire had been tested before fielding the questionnaire.	5,6
Open survey versus closed survey	An "open survey" is a survey open for each visitor of a site, while a closed survey is only open to a sample which the investigator knows (password-protected survey).	5
Contact mode	Indicate whether or not the initial contact with the potential participants was made on the Internet. (Investigators may also send out questionnaires by mail and allow for Web-based data entry.)	6
Advertising the survey	How/where was the survey announced or advertised? Some examples are offline media (newspapers), or online (mailing lists – If yes, which ones?) or banner ads (Where were these banner ads posted and what did they look like?). It is important to know the wording of the announcement as it will heavily influence who chooses to participate. Ideally the survey announcement should be published as an appendix.	6, Appendix 3
Web/E-mail	State the type of e-survey (eg, one posted on a Web site, or one sent out through e-mail). If it is an e-mail survey, were the responses entered manually into a database, or was there an automatic method for capturing responses?	6
Context	Describe the Web site (for mailing list/newsgroup) in which the survey was posted. What is the Web site about, who is visiting it, what are visitors normally looking for? Discuss to what degree the content of the Web site could pre-select the sample or influence the results. For example, a	6

	survey about vaccination on a anti-immunization Web site will have different results from a Web survey conducted on a government Web site	
Mandatory/voluntary	Was it a mandatory survey to be filled in by every visitor who wanted to enter the Web site, or was it a voluntary survey?	5
Incentives	Were any incentives offered (eg, monetary, prizes, or non-monetary incentives such as an offer to provide the survey results)?	6
Time/Date	In what timeframe were the data collected?	6
Randomization of items or questionnaires	To prevent biases items can be randomized or alternated.	N/A
Adaptive questioning	Use adaptive questioning (certain items, or only conditionally displayed based on responses to other items) to reduce number and complexity of the questions.	N/A
Number of Items	What was the number of questionnaire items per page? The number of items is an important factor for the completion rate.	6, Appendix 2
Number of screens (pages)	Over how many pages was the questionnaire distributed? The number of items is an important factor for the completion rate.	6
Completeness check	It is technically possible to do consistency or completeness checks before the questionnaire is submitted. Was this done, and if “yes”, how (usually JAVAScript)? An alternative is to check for completeness after the questionnaire has been submitted (and highlight mandatory items). If this has been done, it should be reported. All items should provide a non-response option such as “not applicable” or “rather not say”, and selection of one response option should be enforced.	6
Review step	State whether respondents were able to review and change their answers (eg, through a Back button or a Review step which displays a summary of the responses and asks the respondents if they are correct).	6
Unique site visitor	If you provide view rates or participation rates, you need to define how you determined a unique visitor. There are different techniques available, based on IP addresses or cookies or both.	6
View rate (Ratio of unique survey visitors/unique site visitors)	Requires counting unique visitors to the first page of the survey, divided by the number of unique site visitors (not page views!). It is not unusual to have view rates of less than 0.1 % if the survey is voluntary.	N/A

Participation rate (Ratio of unique visitors who agreed to participate/unique first survey page visitors)	Count the unique number of people who filled in the first survey page (or agreed to participate, for example by checking a checkbox), divided by visitors who visit the first page of the survey (or the informed consents page, if present). This can also be called "recruitment" rate.	7
Completion rate (Ratio of users who finished the survey/users who agreed to participate)	The number of people submitting the last questionnaire page, divided by the number of people who agreed to participate (or submitted the first survey page). This is only relevant if there is a separate "informed consent" page or if the survey goes over several pages. This is a measure for attrition. Note that "completion" can involve leaving questionnaire items blank. This is not a measure for how completely questionnaires were filled in. (If you need a measure for this, use the word "completeness rate".)	N/A – Because if programmes were cancelled they weren't able to progress to the end page.
Cookies used	Indicate whether cookies were used to assign a unique user identifier to each client computer. If so, mention the page on which the cookie was set and read, and how long the cookie was valid. Were duplicate entries avoided by preventing users access to the survey twice; or were duplicate database entries having the same user ID eliminated before analysis? In the latter case, which entries were kept for analysis (eg, the first entry or the most recent)?	N/A
IP check	Indicate whether the IP address of the client computer was used to identify potential duplicate entries from the same user. If so, mention the period of time for which no two entries from the same IP address were allowed (eg, 24 hours). Were duplicate entries avoided by preventing users with the same IP address access to the survey twice; or were duplicate database entries having the same IP address within a given period of time eliminated before analysis? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	6
Log file analysis	Indicate whether other techniques to analyze the log file for identification of multiple entries were used. If so, please describe.	N/A
Registration	In "closed" (non-open) surveys, users need to login first and it is easier to prevent duplicate entries from the same user. Describe how this was done. For example, was the survey never displayed a second time once the user had filled it in, or was the username stored together with the survey results and later eliminated? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	N/A

Handling of incomplete questionnaires	Were only completed questionnaires analyzed? Were questionnaires which terminated early (where, for example, users did not go through all questionnaire pages) also analyzed?	6
Questionnaires submitted with an atypical timestamp	Some investigators may measure the time people needed to fill in a questionnaire and exclude questionnaires that were submitted too soon. Specify the timeframe that was used as a cut-off point, and describe how this point was determined.	6
Statistical correction	Indicate whether any methods such as weighting of items or propensity scores have been used to adjust for the non-representative sample; if so, please describe the methods.	N/A

Appendix 2 - Electronic survey

Using technology to deliver the exercise component of cardiac rehabilitation

Start of Block: Default Question Block

Background Information Cardiac Rehabilitation is a vital treatment for patients recovering from a cardiac event. Exercise is a core component of a comprehensive cardiac rehabilitation programme, however, the outbreak of Covid-19 has meant that patients in many countries can no longer attend assessments and exercise classes in person. As a consequence, healthcare services have had to adopt new ways of working to ensure that their patients continue to receive cardiac rehabilitation services. Anecdotal evidence suggests that some cardiac rehabilitation services have begun using technology to deliver their assessments, physical activity advice, and/or exercise programmes remotely. The Covid-19 outbreak may therefore represent a step-change in services capacity to use the technology when the disease is brought under control. This may provide an opportunity to increase participation in cardiac rehabilitation among those who are unable or unwilling to travel to centre-based cardiac rehabilitation. This brief survey is designed to help the British Association for Cardiovascular Prevention and Rehabilitation understand if, or how, technology is being used to deliver the exercise component of cardiac rehabilitation. It will also capture professional experiences of using technology to deliver exercise-based cardiac rehabilitation and obtain an estimate of the patient demographic that are engaging with alternative delivery methods of cardiac rehabilitation.

Page Break

Thank you for taking the time to complete our brief survey. It should take approximately 10 minutes to complete.We have asked you to complete this survey because you are involved in the delivery of exercise-based cardiac rehabilitation and we want to understand how your practice has changed in relation to the COVID-19 outbreak. By proceeding to the next page of the survey you are providing consent to take part in the study. Only information that is essential to answer our research question will be collected. Any information collected will be helpful, and will be processed in accordance with the General Data Protection Regulation (2018). If you would like to withdraw from the study, just exit the web page. We will keep the responses you have provide even if you don't complete the whole survey. If you would like any information about data protection or the study, please contact: Dr Simon Nichols Advanced Wellbeing Research Centre Collegiate Hall Collegiate Crescent Sheffield Hallam University S10 2BP s.j.nichols@shu.ac.uk

○ Next page (1)

Page Break

Screening Q Have you previously completed this questionnaire?

- ○ Yes (1)
- ○ No (2)

Q1 Which phase of cardiac rehabilitation do you work in: (please tick the phase which you spend most of your time)

- ○ Phase I (1)
- ○ Phase II (2)
- ○ Phase III (3)
- ○ Phase IV (4)

Q2 Which country do you work in?

- ○ England (1)
- ○ Northern Ireland (2)
- ○ Scotland (3)
- ○ Wales (4)
- ○ Non-UK (please state) (5) _____

Page Break

Q3 Have you continued to provide exercise-based cardiac rehabilitation services during the COVID-19 outbreak?

- Yes – We are able to see as many patients as we did before the COVID-19 outbreak (1)
- Yes – But we aren't able to see as many patients as we did before the COVID-19 outbreak (2)
- No – All services have been cancelled/there are no staff to run our programmes (3)

Q4 Since the COVID-19 outbreak, has your service found that:

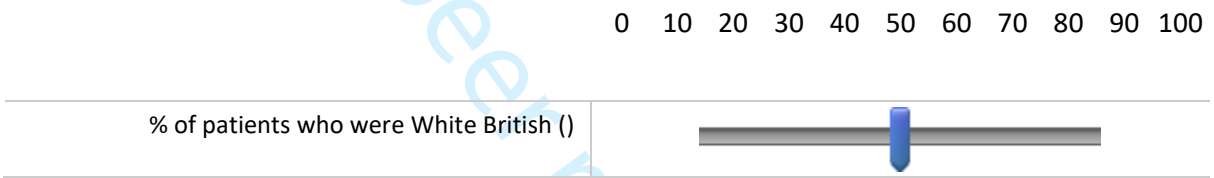
- The same number of patients are accessing exercise-based cardiac rehabilitation (1)
- Fewer patients are accessing exercise-based cardiac rehabilitation (2)
- No patients are accessing exercise-based cardiac rehabilitation (3)

Page Break

Q5 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to ethnicity?

- ☐ No - my patient population is less diverse (1)
- ☐ Yes - my patient population is as diverse as normal (2)
- ☐ No - my patient population is more diverse (3)

Q6 Only answer this question if you are a UK centre. Approximately what percentage of the patients you saw in the last 7 days were White British?

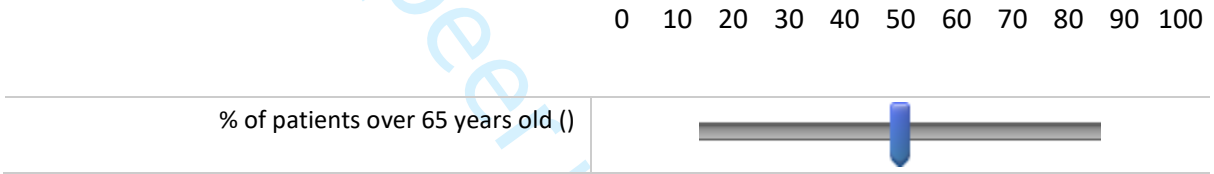


Page Break

Q7 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to age?

- ○ No - my patient population is younger (1)
- ○ Yes - the age group of my patients is similar to normal (2)
- ○ No - my patient population is older (3)

Q8 Approximately what percentage of the patients you saw in the last 7 days were over 65 years old?



Page Break

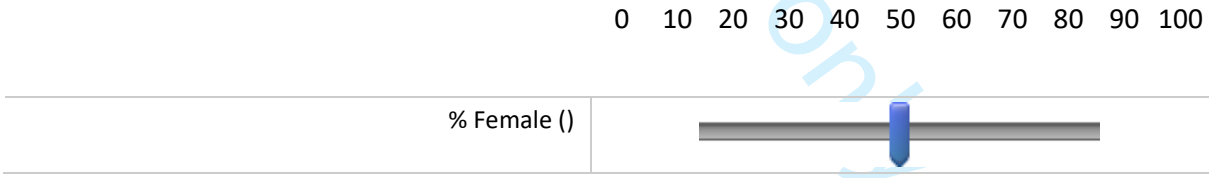
Q9 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to female participation?

- ○ No - the proportion of female participants is smaller (1)
- ○ Yes - the proportion of female participants is the same (2)
- ○ No -the proportion of female participants is larger (3)

Q10 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to male participation?

- ○ No - the proportion of male participants is smaller (1)
- ○ Yes - the proportion of male participants is the same (2)
- ○ No - the proportion of male participants is larger (3)

Q11 Approximately what percentage of the patients you saw in the last 7 days were female?



Page Break

Q12 Are you using any of the following technology to deliver a cardiac rehabilitation exercise assessment? (tick all that apply)

- ☐ Paper/postal services (1)
- ☐ Telephone (2)
- ☐ Text messaging (3)
- ☐ E-mail (4)
- ☐ Recorded video e.g. YouTube (5)
- ☐ Live video conferencing e.g. Zoom, Skype, Microsoft Teams, Facebook (6)
- ☐ Other (please state) (7) _____

Q13 How are you assessing functional capacity during your assessment? (tick all that apply)

- ☐ I am not assessing functional capacity (1)
- ☐ Self-reported fitness (2)
- ☐ Duke Activity Status Index/Other questionnaire (3)
- ☐ Step count from patients own physical activity tracker (4)
- ☐ Remotely supervised exercise test (please state which test) (5)

_____

- ☐ Other (please state) (6) _____

Q14 Are you using any of the following technology to deliver the physical activity/exercise component of cardiac rehabilitation? (tick all that apply)

- ☐ Paper/postal services (1)
- ☐ Telephone (2)
- ☐ Text messaging (3)
- ☐ E-mail (4)
- ☐ Recorded video e.g. YouTube (5)
- ☐ Live video conferencing e.g. Zoom, Skype, Microsoft Teams, Facebook (6)
- ☐ Other (please state) (7) _____

Page Break

Q15 Did you use this technology before the COVID-19 restrictions?

- ○ Yes (1)
- ○ No (2)

Q16 On approximately what date did you start using this technology?

_____

Q17 If you used remote technology before the COVID-19 restrictions, have you found that:

- ○ The same number of patients are accessing exercise-based cardiac rehabilitation using technology (1)
- ○ Fewer patients are accessing exercise-based cardiac rehabilitation using technology (2)
- ○ No patients are accessing exercise-based cardiac rehabilitation using technology (3)

Page Break

Q18 Are you able to use technology to deliver exercise-based cardiac rehabilitation to: (tick all that apply)

- ☐ Low risk patients (1)
- ☐ Moderate risk patients (2)
- ☐ High risk patients (3)

Q19 I am able to offer physical activity recommendations to patients that have not had an assessment in person? (i.e. in the same room as the assessor)

- ○ Yes (1)
- ○ No (2)

Q20 I am able to offer an exercise prescription to patients that have not had an assessment in person? (i.e. in the same room as the assessor)

- ○ Yes (1)
- ○ No (2)

*

Q21 Can you briefly describe what kind of physical activity recommendations you are making and/or exercises you are prescribing?

Examples may include chair-based exercise, resistance bands, walking, running on the spot and body weight exercises.

_____

_____

Page Break

Q22 How many supervised physical activity/exercise training sessions can a patient attend, each week?

_____

Q23 Are the physical activity/exercise sessions you are supervising: (tick all that apply)

- ☐ Group exercise (1)
- ☐ One-on-one (2)

*

Q24 How long is each supervised physical activity/exercise session? Please provide your answer in minutes.

_____

Page Break

Q25 How many unsupervised physical activity/exercise training sessions are you prescribing for a patient, each week?

_____

Q26 How long is each unsupervised physical activity/exercise session? Please provide your answer in minutes.

_____

Page Break

Q27 What intensity range do you recommend/prescribe? (tick all that apply)

- [ ] Low (e.g. RPE 11) (1)
- [ ] Moderate (e.g. RPE 13) (2)
- [ ] High (e.g. RPE 15) (3)

Q28 Is this intensity: (Tick one option only)

- ○ Lower than normal (1)
- ○ The same as normal (2)
- ○ Higher than normal (3)

Page Break

29 Do you think that the programmes you are providing are: (Tick one option only)

- ○ More effective than normal (1)
- ○ As effective as normal (2)
- ○ Less effective than normal (3)

Page Break

Q30 What barriers have you encountered when using technology to deliver cardiac rehabilitation? (tick all that apply)

- ☐ No barriers (1)
- ☐ Patients have no internet connection (2)
- ☐ Patients do not have access to computers/tablets/smart phone (3)
- ☐ Patients are not confident in using technology (4)
- ☐ Patients are concerned about personal safety (5)
- ☐ Patient lack of interest in receiving services using technology (6)
- ☐ My Trust/Health Board /employer do not support the delivery of health services using technology (7)
- ☐ Internet security and patient confidentiality concerns (8)
- ☐ Professionals are not confident in delivering services using technology (9)
- ☐ Professionals are concerned about patient safety (10)
- ☐ Other (please specify) (11) _____

Page Break

Q31 How many adverse events resulting in minor injury have been reported since you have started delivering cardiac rehabilitation remotely? Please only report incidents that are related to exercise-based cardiac rehabilitation.

_____

Page Break

Q32 How many adverse events resulting in life changing injury have been reported since you have started delivering cardiac rehabilitation remotely? Please only report incidents that are related to exercise-based cardiac rehabilitation.

_____

Page Break

Q33 How many adverse events resulting in death have been reported since you have started delivering cardiac rehabilitation remotely? Please only report incidents that are related to exercise-based cardiac rehabilitation.

_____

Page Break

Q34 Do you think that the way you are using technology now should be an option for patients in your future standard practice?

- ○ Yes (1)
- ○ No (2)

Page Break

*

Q35 Is there anything else you would like to tell us about your experience or approaches to delivering exercise-based cardiac rehabilitation using remote technology? (500 characters max)

_____

_____

_____

_____

_____

End of Block: Default Question Block

Appendix 3 - Recruitment material

Appendix 3a - E-mail to BACPR members on 2nd and 25th of June 2020

BACPR Survey - Use of remote technology to deliver the exercise component of cardiac rehabilitation.

Dear Member,

The outbreak of Covid-19 has meant that patients in many countries can no longer attend assessments and exercise classes in person. As a consequence, many healthcare services have had to adopt new ways of working to ensure that their patients continue to receive cardiac rehabilitation services. Anecdotal evidence suggests that some cardiac rehabilitation services have begun to use technology to deliver their assessments, physical activity advice, and/or exercise programmes, remotely. The Covid-19 outbreak may therefore represent a step-change in services capacity to use the technology when the disease is brought under control. This may provide an opportunity to increase participation in cardiac rehabilitation among those who are unable or unwilling to travel to centre-based cardiac rehabilitation, in the long-term.

To help improve the provision of cardiac rehabilitation in the future, we would be extremely grateful if you could take 10 minutes to complete a brief survey which will help the British Association for Cardiovascular Prevention and Rehabilitation understand if, or how, technology is being used to deliver the exercise component of cardiac rehabilitation. It will also capture your professional experiences of using technology to deliver exercise-based cardiac rehabilitation and obtain an estimate of the patient demographic that are engaging with alternative delivery methods of cardiac rehabilitation. The findings of the study will be disseminated through the BACPR as well as conferences, scientific publications, and if appropriate, training courses.

The survey can be completed on a desktop computer or a smart phone, and will take approximately 10 minutes. To proceed to the survey, click here.

Thank you for taking the time to consider taking part in this study.

Best wishes

Dr Simon Nichols

Simon Nichols

BACPR Scientific Chair

British Association for Cardiovascular Prevention & Rehabilitation

c/o BCS, 9 Fitzroy Square,

London

W1T 5HW

www.bacpr.com

Appendix 3b - Example Twitter advert posted on Twitter by the study authors on June 3rd 2020

RT #COVID19 is an unprecedented challenge to #cardiacrehab Please tell us if/how you are using technology to deliver the exercise component of CR by completing this 10 minute survey Down pointing backhand index https://shusls.eu.qualtrics.com/jfe/form/SV_eEgClDLGhsAE7Fr?Q_CHL=social&Q_SocialSource=twitter @bacpr @A_ODoherty @susandawkes @aynsleycowie @drtom_butler @SHU_PAWPH

Example advert posted by the BACPR Exercise Instructor Network on their Facebook page, on 8th June 2020

Appendix 3c - Calling all BACPR Members please check your email inboxes!!

We would greatly appreciate your help in completing our survey regarding the use of remote technology to deliver the exercise component of Cardiac Rehab. The findings of this study will be disseminated through the BACPR, conferences & scientific publications.

BMJ Open

A BACPR survey evaluating the use of technology in cardiac rehabilitation during the COVID-19 pandemic: insights for future practice

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-046051.R1
Article Type:	Original research
Date Submitted by the Author:	18-Feb-2021
Complete List of Authors:	O'Doherty, Alasdair; Northumbria University, Department of Sport, Exercise and Rehabilitation Humphreys, Helen; Sheffield Hallam University, Sport and Physical Activity Research Centre; Sheffield Hallam University, Advanced Wellbeing Research Centre Dawkes, Susan; Edinburgh Napier University, Cowie, Aynsley ; University Hospital Crosshouse, Cardiac Rehabilitation Hinton, Sally; British Association for Cardiovascular Prevention and Rehabilitation Brubaker, Peter; Wake Forest University, Department of Health and Exercise Science Butler, Tom; Edge Hill University Faculty of Health and Social Care Nichols, Simon; Sheffield Hallam University, Sport and Physical Activity Research Group; Sheffield Hallam University, Advanced Wellbeing Research Centre
Primary Subject Heading:	Cardiovascular medicine
Secondary Subject Heading:	Rehabilitation medicine, Sports and exercise medicine, Public health, Health services research, Cardiovascular medicine
Keywords:	REHABILITATION MEDICINE, Telemedicine < BIOTECHNOLOGY & BIOINFORMATICS, COVID-19, Adult cardiology < CARDIOLOGY

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A BACPR survey evaluating the use of technology in cardiac rehabilitation during the COVID-19 pandemic: insights for future practice

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Abstract

Objective: To investigate whether exercise-based cardiac rehabilitation services continued during the COVID-19 pandemic, and investigate how technology has been used to deliver home-based cardiac rehabilitation.

Design: A mixed methods survey, including questions about exercise-based cardiac rehabilitation service provision, programme diversity, patient complexity, technology use, barriers to using technology, and safety.

Setting: International survey of exercise-based cardiac rehabilitation programmes

Participants: Healthcare professionals working in exercise-based cardiac rehabilitation programmes, worldwide.

Main outcome measures: The proportion of programmes that continued providing exercise-based cardiac rehabilitation, and which technologies had been used to deliver home-based cardiac rehabilitation.

Results: Three-hundred and thirty eligible responses were received; 89.7% were from the UK. Approximately half (49.3%) of respondents reported that CR programmes were suspended due to COVID-19. Of programmes that continued; 25.8% used technology before the COVID-19 pandemic. Programmes typically started using technology within 19 days of COVID-19 becoming a pandemic. 48.8% did not provide CR to high-risk patients, telephone was most commonly used to deliver CR, and some centres used sophisticated technology such as teleconferencing.

Conclusions: The rapid adoption of technology into standard practice is promising and may improve accessibility, or participation, in exercise-based CR beyond COVID-19. However, the exclusion of certain patient groups and programme suspension, could worsen clinical symptoms and wellbeing, and increase hospital admissions. Refinement of current practices, with a focus on improving

inclusivity and addressing safety concerns around exercise support to high-risk patients, may be needed.

Abstract: 233 Words

Key words: Cardiac rehabilitation, COVID-19, Telehealth, Exercise training,

Article Summary

Strengths and limitations of this study

- This is the first international reporting on the effect that COVID-19 restrictions have had on exercise-based cardiac rehabilitation.
- We report data from *n*=330 cardiac rehabilitation programmes around the world, although the majority of data were from the United Kingdom.
- Our mixed methods survey enabled us to investigate how technology has been used to deliver exercise-based cardiac rehabilitation, as well the barriers to using technology.
- Respondents were only able to complete the survey once, but we could have received more than one response from professionals working in a single cardiac rehabilitation programme.
- Our data could be used to inform future research agendas, international healthcare policy, and local healthcare decision making.

Financial support

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Competing interests

SN has received funding from Research England, via the Advanced Wellbeing Research Centre Accelerator, to evaluate the effect of a technology platform for cardiac rehabilitation developed by Aseptika Ltd. SN, AFO, AC, and HH have received funding from AstraZeneca to investigate factors

influencing uptake on to cardiac rehabilitation. SN, SD, TB, and AC are members of the BACPR Council. SD received funding from the Burdett Trust to investigate uptake on to exercise referral schemes. SD participated in cardiovascular prevention advisory board for AstraZeneca. SH is Executive Director of the British Association for Cardiovascular Prevention and Rehabilitation (BACPR). PB has received funding from the National Institute of Health for Cardiac Rehabilitation-related research. PB has also received consultation fees and honoraria from Merck, Ingelheim Boehringer, Corvia Medical, and Boston Scientific.

Introduction

Cardiac rehabilitation (CR) is a comprehensive programme of secondary prevention interventions for patients with heart disease, encompassing support for psychosocial health, medical risk management and cardiovascular risk factor modification, including exercise training [1]. Exercise-based CR reduces cardiovascular deaths and recurrent myocardial infarction within 10 years, hospital admissions within 2 years, and improves health-related quality of life [2-5]. Despite these benefits, only 49% (n=141,648) of eligible United Kingdom (UK) patients enrolled on to a CR programme between 2012 and 2015 [6]. Increasing uptake to 65% could lead to 21,000 fewer hospital admissions and 8,500 fewer deaths over 10 years [7]. In response, NHS England set an ambitious target to increase CR uptake to 85% by 2029 [8].

COVID-19 is spread by a highly contagious virus. As of September 2020, it has infected 26,121,999 and has killed 864,618 people worldwide [9]. The rapid spread of COVID-19 infections resulted in governments imposing restrictions on face-to-face human contact [10]. Numerous 'non-essential' healthcare services were suspended and patient attendance to continuing services has decreased due to fear of contracting COVID-19 [11, 12]. The COVID-19 pandemic may therefore undermine efforts to increase uptake to exercise-based CR.

Before COVID-19, expanding the availability of home-based programmes was recommended to increase participation in exercise-based CR [13]. This is partly due to a lack of capacity within existing face-to-face services [14]. Yet, in 2019, 8.8% of UK CR patients participated in home-based programmes [15]. The recent suspension of face-to-face healthcare services may have led to programmes rapidly adopting home-based, technology facilitated services. Data from urgent and non-urgent care centres in the United States of America (USA) reported that teleconferencing consultations increased from 82 on March 4th 2020, to 1336 on 19th March 2020 [16]. If a similar rate of technology adoption occurred in CR, this could have helped to maintain patient participation. These methods could also be adopted in to future standard practice to increase accessibility and subsequent uptake onto CR programmes.

The aim of this mixed-methods survey, conducted in collaboration with the British Association for Cardiovascular Prevention and Rehabilitation (BACPR), was to investigate whether exercise-based CR services continued during the COVID-19 pandemic. We also evaluated whether technology was used to deliver exercise-based CR, and the professional experiences of this technology, during the COVID-19 pandemic.

Materials and Methods

Survey development

The methods and results are reported in conjunction with the Checklist for Reporting Results of Internet E-surveys (CHERRIES; Appendix 1) [17]. This voluntary, cross-sectional, international, open survey, targeted at a convenience sample of healthcare professionals in exercise-based CR, was developed by SN and AFO. The broad topic of questions, relating to the COVID-19 pandemic, were:

1. If and how CR services were provided.
2. The demographics and medical complexity of patients accessing CR services.
3. How technology was used to undertake patient assessments and deliver the exercise component of CR.
4. The barriers encountered when using technology to deliver the exercise component of CR.

The survey was reviewed by the members of the BACPR elected Council prior to ethical approval, and amended accordingly. The BACPR council includes physicians, nurses, physiotherapists, exercise physiologists, exercise instructors, psychologists, dietitians, and occupational therapists. The resulting 35-item questionnaire was uploaded to the Qualtrics^{XM} online survey platform (Provo, Utah, USA). Qualtrics has ISO/IEC 27001 security certification. The automated database was password protected and stored on secure Qualtrics and Sheffield Hallam University servers. The survey was presented

across 21 pages, including background information and consent. There were 22 tick box items (19 mandatory), seven mandatory numerical responses, three non-mandatory sliding bar responses, two non-mandatory free-text responses, and one mandatory date entry response. Four questions also permitted free-text responses under the option 'other'. Response validation was used on all questions, where appropriate. Survey progress was displayed on each page. Participants did not have a completeness check/review option at the end of the survey. Participants were only able to visit the website once from the same IP address, and they had seven days to complete the survey once started. The functionality of the survey was tested by SN, AOD, SD, SH, and AC. The final version of the online survey (Appendix 2), was given institutional ethical approval by Sheffield Hallam University (ID: ER24303491), on the 29th May 2020. All participants provided informed consent, and all study procedures were carried out following the rules of the Declaration of Helsinki of 1975 (https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/), revised in 2013.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Survey dissemination

On 2nd June 2020, a recruitment e-mail was sent to BACPR members; 746 healthcare professionals and academics working in CR. This was repeated on June 25th 2020. The survey was also promoted on social media platforms (Appendix 3). A link to the survey *was not* posted on any website. The survey closed at 12pm on 31st July 2020. There were no incentives offered for participation.

Quantitative data analysis

Categorical data are reported as the number of responses, expressed as a percentage (%) of the respondents to each question. Continuous data are reported as median, with minimum and maximum values. Responses were reported for the full cohort, and by the Phase of CR that the respondents worked in. Phase I was defined as the inpatient stage, Phase II as the early discharge phase, Phase III as a clinically supervised outpatient programme, and Phase IV as long-term physical activity maintenance. The number of responses to each question varied and are detailed in Tables 1 and 2, and Appendix 4. Tests of statistical significance were not conducted.

Qualitative Data analysis

Free text answers were exported into NVivo 11 software for thematic analysis. Answers were coded inductively. The resulting coding framework was then reviewed to identify patterns and themes in the data. Similar codes were grouped to form lower order themes, which were then grouped into higher order themes. Each theme was given a descriptive explanation with illustrative quotes.

Results

Responses

Four-hundred and seven visits to the survey site were recorded. Seventy-seven (18.9%) did not progress past the study information and consent page (81.1% participation rate). Three-hundred and thirty responses were analysed, 296 (89.7%) were from the UK. The remaining responses were from Japan (*n*=8; 2.4%), Australia (*n*=4*;* 1.2%), the USA (*n*=4*;* 1.2%), Republic of Ireland (*n*=4*;* 1.2%), Gibraltar (*n*=2*;* 0.6%), India (*n*=2*;* 0.6%), South Africa (*n*=2*;* 0.6%), Spain (*n*=2*;* 0.6%), the Bailiwick of Guernsey (*n*=1*;* 0.3%), Canada (*n*=1*;* 0.3%), the Isle of Man (*n*=1*;* 0.3%), and Kuwait *n*=1*;* (0.3%).

Service provision during COVID-19

At the time of responding, 163 (49.3%) CR programmes had been suspended due to COVID-19 (Table 1). The proportion of UK (*n*=147*;* 49.7%) and non-UK (*n*=16; 47.1%) services that had been suspended were similar. Phase IV programmes were most likely to have suspended all activities (*n*=89; 72.4%; Table 1). The remaining questions in the survey were applicable to a maximum of 167 respondents. The number of responses to each question can be seen Table 1 and Appendix 4.

Following COVID-19 restrictions, 32 (19.9%) programmes reported that the same volume of patients were choosing to access their service (Table 1). Most programmes reported that either fewer patients (*n*=111; 68.9%), or no patients (*n*=18; 11.2%) were choosing to access their service (Table 1). Programmes believed that patients enrolling in CR were either as demographically as diverse' (*n*=122; 80.8%), or more diverse, than normal (*n*=7; 4.6%; Table 1). UK CR programmes also estimated that 90.4% (0.0 to 100.0%) of patients seen in the last seven days were 'White British'. Most CR programmes (92.5%) reported that the age of participants was similar to normal, with 70% (0.0 to 100.0%) of patients enrolling in CR >65 years of age (Table 1). Programmes also reported that the sex of patients participating in CR was proportionally similar to normal. Female participation in CR was estimated at 30% (0.0 to 80%; Table 1).

Technology adoption

Figure 1 shows the increase in adoption of technology over time. The earliest date that a programme reported using technology was the 10th January 2010. The latest was the 20th June 2020. Thirty-three (25.8%) used technology to deliver exercise-based CR before COVID-19 was declared a pandemic by the World Health Organisation (WHO) [18]. The median date of technology adoption was 30th March 2020. There were notable increases in technology adoption, the first coincided with the release of the UK's NHS long-term plan [8]. The second, more rapid increase, coincides with COVID-19 pandemic [18].

Technology use in patient assessment

The most commonly used technology was telephone (*n*=113; 85.0%; Figure 2). 24.1% (*n*=32) of programmes reported that they were not assessing or estimating functional capacity. Practitioners mostly relied on patient self-reported fitness to estimate functional capacity (*n*=92; 69.2%). Some programmes estimated functional capacity by using a questionnaire (26.3%, *n*=35), or the patient's own physical activity tracker (21.1%, *n*=28). One Phase I (16.7%), two phase II (14.3%), and four Phase IV CR programmes (13.8%) remotely supervised exercise testing (Figure 2).

Table 1 – Provision of cardiac rehabilitation services during the COVID-19 pandemic, displayed as number (%)

	All	Phase I	Phase II	Phase III	Phase IV
Service status	(*n*=330)	(*n=14)*	(*n*=29)	(*n*=164)	(*n*=123)
Services able to see as many patients as usual	44 (13.3)	2 (14.3)	6 (20.7)	30 (18.3)	6 (4.9)
Service able to see fewer patients	123 (37.3)	6 (42.9)	12 (41.4)	77 (47.0)	28 (22.8)
Service suspended (%)	163 (49.4)	7 (42.9)	11 (37.9)	57 (34.8)	89 (72.4)
Patients accessing cardiac rehabilitation	(*n*=161)	(*n=8)*	(*n*=17)	(*n*=102)	(*n*=34)
No patients are accessing the service	18 (11.2)	2 (25.0)	3 (17.6)	9 (8.8)	4 (11.8)
Fewer patients are accessing the service	111 (68.9)	5 (62.5)	13 (76.5)	65 (63.7)	28 (82.4)
Same number of patients are accessing the service	32 (19.9)	1 (12.5)	1 (5.9)	28 (27.5)	2 (5.9)
Diversity of cardiac rehabilitation	(*n*=151)	(*n=7)*	(*n*=16)	(*n*=95)	(*n*=33)
Patient population is less diverse than before COVID-19	22 (14.6)	3 (42.9)	1 (6.25)	13 (13.7)	5 (15.2)
Patient population is as diverse as it was before COVID-19	122 (80.8)	4 (57.1)	15 (93.8)	78 (82.1)	25 (75.8)
Patient population is more diverse than before COVID-19	7 (4.6)	0 (0.0)	0 (0.0)	4 (4.2)	3 (9.1)
Patient population is younger than before COVID-19	6 (4.1)	0 (0.0)	2 (13.3)	2 (2.2)	2 (6.3)
Patient population is similar to what is was before COVID-19	135 (92.5)	5 (71.4)	12 (80.0)	89 (96.7)	29 (90.6)
Patient population is older than before COVID-19	5 (3.4)	2 (28.6)	1 (6.7)	1 (1.1)	1 (3.1)
Estimated percentage of patients in the last 7 days that were >65 years?	70.0 (0.0 to 100.0)	75.0 (60.0 to 85.0)	67.0 (38.0 to 100.0)	64.5 (0.0 to 100.0)	80.0 (0.0 to 1000.0)
Proportion of female participation is smaller	11 (0.8)	1 (16.7)	0 (0.0)	8 (9.4)	2 (6.9)
Proportion of female participation is the same	113 (83.7)	4 (66.7)	14 (93.3)	69 (81.2)	26 (89.7)
Proportion of female participation is larger	11 (0.8)	1 (16.7)	1 (6.7)	8 (9.4)	1 (3.4)
Proportion of male participation is smaller	6 (4.4)	1 (16.7)	1 (6.7)	2 (2.4)	2 (7.0)
Proportion of male participation is the same	123 (91.1)	4 (66.7)	14 (93.3)	79 (92.9)	26 (89.7)
Proportion of male participation is larger	6 (4.4)	1 (16.7)	0 (0.0)	4 (4.7)	1 (3.4)
Estimated percentage of patients in the last 7 days were female?	30.0 (0.0 to 80.0)	40.0 (10.0 to 70.0)	30.0 (1.0 to 57.0)	30.0 (0.0 to 80.0)	40.0 (1.0 to 73.0)

Technology use in physical activity and exercise prescription

Most services were able to provide physical activity advice (*n*=102; 82.9%). Seventy-two (58.5%) programmes also offered structured exercise training programmes. Telephone remained the most commonly used technology to facilitate the physical activity or exercise component of CR (*n*=86, 64.7%; Figure 3). Pre-recorded online videos (*n*=69; 51.9%) were also widely used, particularly among Phase III programmes (*n*=54; 64.3%; Figure 3). Most CR services were able to provide physical activity or structured exercise training to patients at low (*n*=117; 95.1%) and moderate risk (*n*=109; 88.6%) of exercise-induced cardiac events. Half (51.2%; *n*=63) were able to offer services to patients at high-risk of exercise-induced cardiac events. Three (2.8%) programmes reported one adverse event resulting in minor injury whilst using technology to deliver the exercise component of CR (three events in total). There were no reports of life changing injury, or death.

Barriers to using technology

The number of responses to each question about barriers to using technology is shown in Table 2. Respondents were asked to state *any* barriers that they encountered when using technology. Only two (1.9%) programmes reported 'no barriers' (Table 2). Most (*n*=93; 86.9%) encountered a "lack of patient confidence" with technology (Table 2). Qualitative analysis of the barriers to using technology fell into two categories; logistical and organisational barriers, and patient-related barriers. Logistical and organisational barriers were largely a result of healthcare organisations being unprepared, and not familiar with using online healthcare delivery. Onerous governance processes or delayed access to the necessary IT equipment were also described. Patient-related barriers were associated with communication (either language or understanding), and concerns that patients were either over-reporting their activity or not following advice provided.

Practitioner experiences

Qualitative analysis of free text answers to the final question allowing "Any other comments" resulted in the identification of three higher order themes; i) impact on patient experience; ii) challenges for staff and iii) implications for future delivery.

i) Impact on patient experience

Survey respondents varied in their views about the impact on patient engagement and experience. Technology was acknowledged as a valuable means of connecting patients with CR staff, but a small number of respondents also highlighted that it was harder to establish a rapport this way. One participant reported a decline in patients' fitness outcomes whilst another claimed that patients exercised harder at home without peers to distract them. More commonly, participants reported that regardless of the perceived benefits of remote delivery, it was difficult to replicate the social benefits associated with group exercise delivery:

> *"The lack of contact with other patients means the patients miss out on the social and emotional support from each other."*

Table 2 –Barriers to using technology in exercise-based cardiac rehabilitation displayed as number (%)

Barriers to using technology	All (*n*=107)	Phase I (*n=6)*	Phase II (*n*=9)	Phase III (*n*=68)	Phase IV (*n*=24)
Lack of patient confidence	93 (86.9)	2 (33.3)	8 (88.9)	60 (88.2)	23 (95.8)
Patients do not have access to computers/tablets/smart phone	86 (80.4)	2 (33.3)	4 (44.4)	61 (89.7)	19 (79.2)
Patients do not have an internet connection	73 (68.2)	2 (33.3)	6 (66.7)	48 (70.6)	17 (70.8)
Patients lack of interest in receiving services using technology	65 (60.7)	1 (16.7)	5 (55.6)	44 (64.7)	15 (62.5)
Professionals are concerned about patient safety	43 (40.2)	0 (0.0)	3 (33.3)	34 (50.0)	6 (25.0)
Patients are concerned about safety	32 (29.9)	2 (33.3)	3 (33.3)	21 (30.9)	6 (25.0)
Internet security and patient confidentiality concerns	27 (25.2)	1 (16.7)	4 (44.4)	18 (25)	4 (16.7)
Professionals not confident delivering service using technology	24 (22.4)	0 (0.0)	2 (22.2)	19 (27.9)	3 (12.5)
Trust/Health Board do not support the delivery of health services using technology	16 (15.0)	1 (16.7)	0 (0.0)	14 (20.6)	1 (4.2)
No barriers	2 (1.9)	1 (11.1)	0 (0.0)	1 (1.5)	0 (0.0)

ii) Challenges for professionals

Survey participants cited a range of challenges to adoption of technology, including the limitations of existing platforms, such as smart device applications for CR. These were described as lacking patient-centred or motivational content and time-consuming to use. Participants reported further difficulties associated with COVID-19 related staff redeployment or illness, and reiterated barriers such as lack of access to technology and organisational delays caused by IT and governance restrictions.

A large number of comments described concerns relating to practitioners' inability to observe patients, limiting safe and accurate assessment of functional capacity. This had resulted in a more cautious approach, with respondents reporting that they prescribed only gentle or low-level exercise:

> *"Our main concern has been the difficulty of not being able to complete functional capacity assessments, we have therefore recommended patients exercise at a lower level than we normally would."*

iii) Implications for future delivery

Many respondents reported optimism about continuing to incorporate technology in future CR delivery. Nevertheless, it was generally recognised that delivery should be flexible. Exercise programmes should be tailored to individual needs and risk levels and patients should be provided with a range of options for engaging with CR, including both face-to-face contact with CR staff and online/home-based exercise.

Several comments indicated opportunities for improvement in the technology available, with one participant suggesting that current formats were driven by NACR audit data requirements as opposed to patient needs. Another respondent called for further research to inform more confident remote exercise prescription:

"Still feel face to face assessment is superior for more frail patients …and for higher risk patients… Nevertheless, I am gaining more confidence in remote assessment, and would be reassured further by some research to demonstrate its safety and efficacy. I already know remote delivery has been shown to be safe and effective, but as far as I am aware this has been evidenced only when prescribed from face to face assessment."

Quantitatively, 94 (88.7%) programmes believed that technology should be available for patients in the future.

Discussion

To our knowledge, this is the first study to quantitatively document the effect that restrictions, imposed due to COVID-19, had on exercise-based CR programmes. We found that nearly half of all programmes had been suspended and that most centres reported a reduction in patient engagement with services during the COVID-19 pandemic. Practitioners reported that the age and sex of patients attending CR was similar to before the COVID-19 pandemic. Technology was rapidly adopted to deliver CR, with less sophisticated technology, such as the telephone, being most widely used. Higher risk patients were less likely to be offered remote CR using technology. Nearly all centres reported barriers to using technology to deliver CR. Finally, despite an openness to adopting technology by practitioners, there were concerns surrounding availability of, and confidence in using technology. Qualitatively, patient assessment, less opportunity for socialisation, and safety were highlighted.

Service provision

COVID-19 has resulted in many non-essential healthcare services being suspended. We have shown that this was true for half of exercise-based CR services. In 2019, 89,573 patients accessed exercise-

based CR in the UK [15], therefore a high proportion of cardiac patients may have been negatively affected by this widespread service disruption. Given that exercise-based CR improves quality of life [4, 19] and reduces hospital admissions [3], suspension of services is likely to result in worsening clinical symptoms, wellbeing, and increased hospital admissions long-term. This may place an increased burden on healthcare services in the coming months. Nevertheless, there was an increase in the use of technology in CR shortly after COVID-19 was declared a Pandemic by the WHO [18]. Comparing long-term patient outcomes from programmes that continued service provision with programmes that were unable to continue will help to determine the effectiveness of these changes.

Technology adoption and barriers

Recent editorials and reviews have suggested that COVID-19 could be a catalyst for large-scale changes in the way that CR is delivered [20, 21]. We found that most services started using technology to deliver home-based exercise-based CR within three weeks of COVID-19 being declared a pandemic by the WHO [18], only three services were providing face-to-face services. This suggests that the capacity of CR services to provide home-based rehabilitation programmes has rapidly increased. If maintained, subject to robust evidence, the potential for increased accessibility, could positively influence participation in CR when face-to-face service have resumed.

Traditional modes of communication such as telephone were most commonly used. Surprisingly few services used tele-conferencing, smart device applications and web-based systems. Healthcare professionals cited that patients often lacked confidence using equipment and/or that patients did not have the required equipment for technology use. The number and sociodemographic profile of patients for whom this was a genuine barrier is unclear. Others have reported that age may be a factor, with people aged 22-44 years most likely use tele-conferencing facilities [16], and people over 65 years being less likely to have a smart phone [22]. This could warrant further investigation to address inequalities in the accessibility of technology-based provision of CR. Meanwhile, professionals'

concern for patient safety (40.2%) and internet security (25.2%) were also likely to contribute to the low uptake of novel technology. Healthcare organisations being underprepared for the adoption of new technology may also play a role, although this was less frequently reported in quantitative analysis. 'Top-down' endorsement of technology by health Trusts, Health Boards or healthcare providers may give healthcare professionals confidence in using technology.

Participation

Participation in CR continued despite COVID-19 restrictions. However, programmes were able to offer services to fewer patients and update was reduced. Furthermore, UK programmes reported that ~90% of participants were 'White British', which is proportionately higher than recently indicated (79%) in the 2019 NACR report [15]. Future research should investigate the direct impact of COVID-19 on minority group participation in exercise-based CR, and explore how to increase their participation when it is delivered using technology. Encouragingly, programmes reported that similar proportions of males and females, and people over the age of 65 years, engaged with CR compared to pre-COVID-19 participation.

Data from our survey showed that 41.5% of programmes were unable to provide exercise-based CR to patients at high-risk of exercise-induced cardiac events. CR should be available to all eligible patients, irrespectively of risk [1]. The development and refinement of future technology-based interventions should be inclusive of all risk levels. Qualitative comments highlighted concerns about using technology to remotely deliver exercise-based CR for frail patients. Safety concerns were also a common feature in our quantitative analysis (Table 2). The wide use of 'offline' delivery modes such as telephone and pre-recorded videos identified in our survey limits the capacity to evaluate physiological information during exercise and the scope for practitioners to tailor advice to the individual. It may be perceived as unsafe for patients at high-risk of exercise-induced event, but not

for lower risk patients. Overcoming these concerns, through robust evidence, may be an important step in negating future health inequalities.

Limitations

The high UK response rate to our survey (*n*=296; 89.7%) makes it likely that our findings are representative of CR in the UK. However, the response rate from CR programmes outside of the UK was low. The generalisability of our findings to the rest of the world may therefore be limited. Additionally, we aimed to recruit healthcare professionals rather than patients. Future research should investigate patient perceptions of using technology in CR so that a more complete understanding of barriers can be reported. We also asked study participants to report on whether they perceived that certain demographics of the patients engaging with their services had changed, therefore we cannot exclude information bias. Finally, individual practitioners rather than centres were targeted to respond. Therefore, the risk of bias could have been increased by multiple practitioners from the same centre completing the survey.

Conclusions

Nearly half of all CR programmes have been suspended during COVID-19 restrictions. Technology was rapidly adopted by CR services which may increase participation beyond COVID-19. However, higher risk patients may be disadvantaged by technology use, whilst people in the UK who are 'White British' may be most likely to benefit for it. Our findings indicate a role for technology in future CR delivery. There is a need for innovation in patient-centred, interactive technological resources that also foster confidence amongst practitioners. Future research needs to investigate the longer-term adoption of technology in CR following COVID-19, and its effects on participation, patient experience and safety.

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Conceptualization: Simon Nichols; **Methodology:** Simon Nichols, Alasdair O'Doherty, Helen Humphreys, Susan Dawkes, Aynsley Cowie, Sally Hinton; **Formal Analysis:** Simon Nichols, Alasdair O'Doherty, Helen Humphreys; **Investigation:** Simon Nichols, Alasdair O'Doherty, Helen Humphreys, Susan Dawkes, Aynsley Cowie, Sally Hinton, Peter Brubaker, Tom Butler; **Data curation:** Simon Nichols, Helen Humphreys; **Writing- Original draft preparation:** Simon Nichols; **Writing - Review & Editing:** Simon Nichols, Alasdair O'Doherty, Helen Humphreys, Susan Dawkes, Aynsley Cowie, Sally Hinton, Peter Brubaker, Tom Butler; **Visualization:** Simon Nichols**; Supervision:** Simon Nichols; **Project Administration:** Simon Nichols

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Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Data sharing

Data will be available, on reasonable request, 18 months after publication of the manuscript. Data can be requested by contacting the corresponding author, or by contacting library-research-support@shu.ac.uk.

Figure 1 – Data showing the use of technology to deliver exercise-based cardiac rehabilitation between January 2010 and June 2020. Black bars indicate how many programmes started using their chosen technology, on a given date. The grey area shows the cumulative number of cardiac rehabilitation programmes using technology.

Figure 2 – Types of technology used to undertake baseline assessments. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

Figure 3 – Types of technology used to deliver the exercise component of cardiac rehabilitation. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

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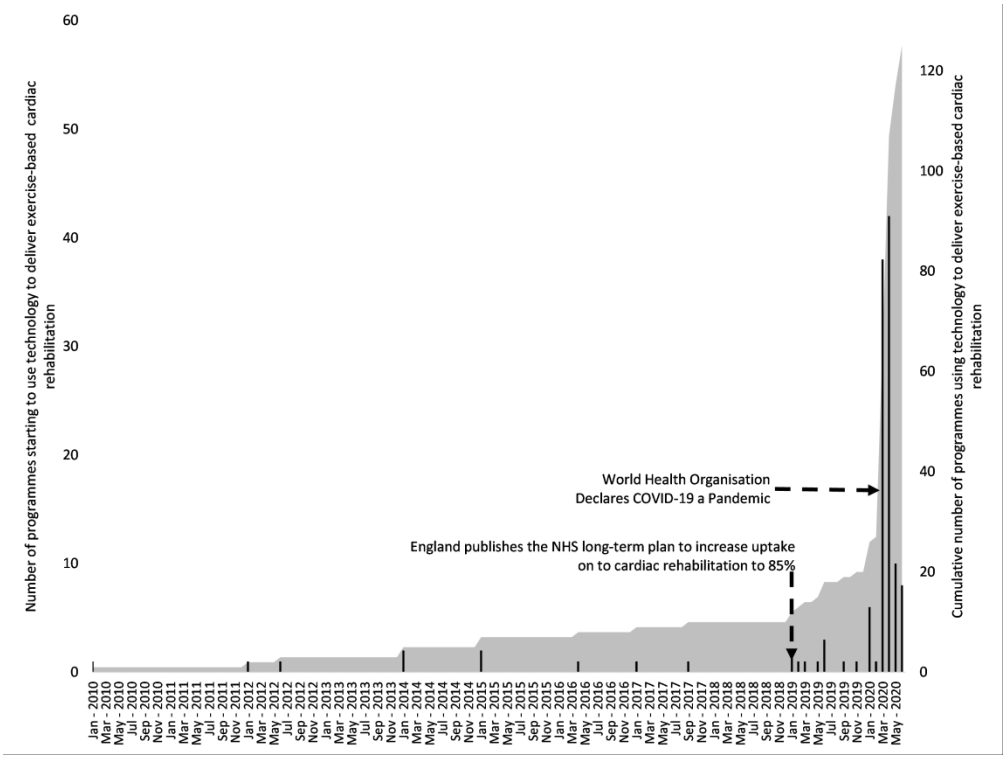


Figure 1 – Data showing the use of technology to deliver exercise-based cardiac rehabilitation between January 2010 and June 2020. Black bars indicate how many programmes started using their chosen technology, on a given date. The grey area shows the cumulative number of cardiac rehabilitation programmes using technology.

250x188mm (300 x 300 DPI)

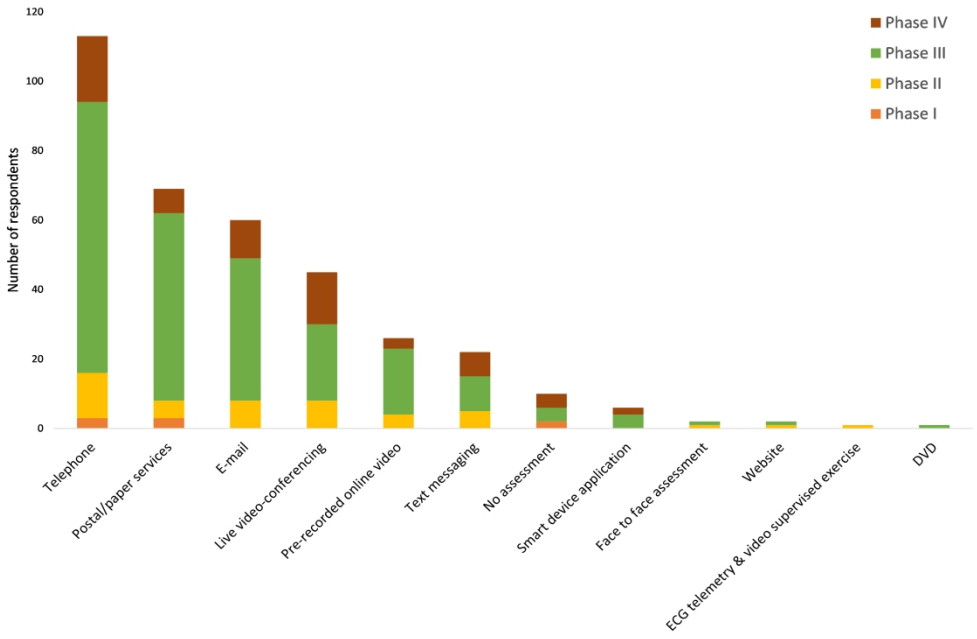


Figure 2 – Types of technology used to undertake baseline assessments. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

272x175mm (300 x 300 DPI)

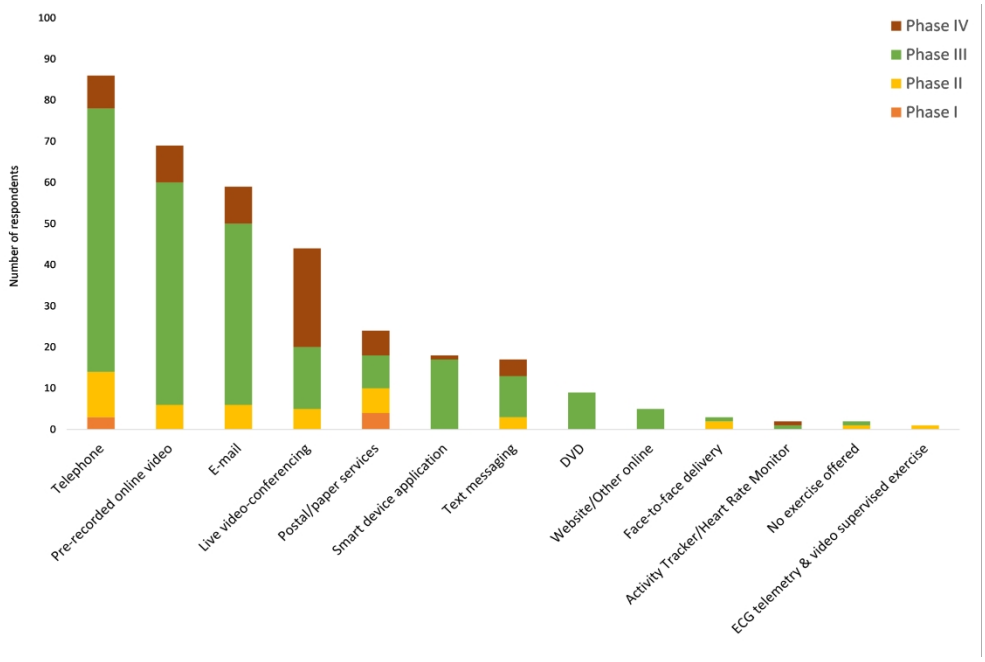


Figure 3 – Types of technology used to deliver the exercise component of cardiac rehabilitation. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

270x176mm (300 x 300 DPI)

Appendix 1 - Checklist for Reporting Results of Internet E-Surveys (CHERRIES)

Checklist Item	***Explanation***	***Page Number***
Describe survey design	Describe target population, sample frame. Is the sample a convenience sample? (In "open" surveys this is most likely.)	7
IRB approval	Mention whether the study has been approved by an IRB.	8
Informed consent	Describe the informed consent process. Where were the participants told the length of time of the survey, which data were stored and where and for how long, who the investigator was, and the purpose of the study?	Page 8 & Appendix 2
Data protection	If any personal information was collected or stored, describe what mechanisms were used to protect unauthorized access.	7
Development and testing	State how the survey was developed, including whether the usability and technical functionality of the electronic questionnaire had been tested before fielding the questionnaire.	7 & 8
Open survey versus closed survey	An "open survey" is a survey open for each visitor of a site, while a closed survey is only open to a sample which the investigator knows (password-protected survey).	7
Contact mode	Indicate whether or not the initial contact with the potential participants was made on the Internet. (Investigators may also send out questionnaires by mail and allow for Web-based data entry.)	8
Advertising the survey	How/where was the survey announced or advertised? Some examples are offline media (newspapers), or online (mailing lists – If yes, which ones?) or banner ads (Where were these banner ads posted and what did they look like?). It is important to know the wording of the announcement as it will heavily influence who chooses to participate. Ideally the survey announcement should be published as an appendix.	8 & Appendix 3
Web/E-mail	State the type of e-survey (eg, one posted on a Web site, or one sent out through e-mail). If it is an e-mail survey, were the responses entered manually into a database, or was there an automatic method for capturing responses?	8
Context	Describe the Web site (for mailing list/newsgroup) in which the survey was posted. What is the Web site about, who is visiting it, what are visitors normally looking for? Discuss to what degree the content of the Web site could pre-select the sample or influence the results. For example, a	8

	survey about vaccination on a anti-immunization Web site will have different results from a Web survey conducted on a government Web site	
Mandatory/voluntary	Was it a mandatory survey to be filled in by every visitor who wanted to enter the Web site, or was it a voluntary survey?	7
Incentives	Were any incentives offered (eg, monetary, prizes, or non-monetary incentives such as an offer to provide the survey results)?	8
Time/Date	In what timeframe were the data collected?	8
Randomization of items or questionnaires	To prevent biases items can be randomized or alternated.	N/A
Adaptive questioning	Use adaptive questioning (certain items, or only conditionally displayed based on responses to other items) to reduce number and complexity of the questions.	N/A
Number of Items	What was the number of questionnaire items per page? The number of items is an important factor for the completion rate.	7, 8 & Appendix 2
Number of screens (pages)	Over how many pages was the questionnaire distributed? The number of items is an important factor for the completion rate.	8
Completeness check	It is technically possible to do consistency or completeness checks before the questionnaire is submitted. Was this done, and if “yes”, how (usually JAVAScript)? An alternative is to check for completeness after the questionnaire has been submitted (and highlight mandatory items). If this has been done, it should be reported. All items should provide a non-response option such as “not applicable” or “rather not say”, and selection of one response option should be enforced.	8
Review step	State whether respondents were able to review and change their answers (eg, through a Back button or a Review step which displays a summary of the responses and asks the respondents if they are correct).	8
Unique site visitor	If you provide view rates or participation rates, you need to define how you determined a unique visitor. There are different techniques available, based on IP addresses or cookies or both.	8
View rate (Ratio of unique survey visitors/unique site visitors)	Requires counting unique visitors to the first page of the survey, divided by the number of unique site visitors (not page views!). It is not unusual to have view rates of less than 0.1 % if the survey is voluntary.	N/A

Participation rate (Ratio of unique visitors who agreed to participate/unique first survey page visitors)	Count the unique number of people who filled in the first survey page (or agreed to participate, for example by checking a checkbox), divided by visitors who visit the first page of the survey (or the informed consents page, if present). This can also be called "recruitment" rate.	9
Completion rate (Ratio of users who finished the survey/users who agreed to participate)	The number of people submitting the last questionnaire page, divided by the number of people who agreed to participate (or submitted the first survey page). This is only relevant if there is a separate "informed consent" page or if the survey goes over several pages. This is a measure for attrition. Note that "completion" can involve leaving questionnaire items blank. This is not a measure for how completely questionnaires were filled in. (If you need a measure for this, use the word "completeness rate".)	N/A – Because if programmes were cancelled they weren't able to progress to the end page.
Cookies used	Indicate whether cookies were used to assign a unique user identifier to each client computer. If so, mention the page on which the cookie was set and read, and how long the cookie was valid. Were duplicate entries avoided by preventing users access to the survey twice; or were duplicate database entries having the same user ID eliminated before analysis? In the latter case, which entries were kept for analysis (eg, the first entry or the most recent)?	N/A
IP check	Indicate whether the IP address of the client computer was used to identify potential duplicate entries from the same user. If so, mention the period of time for which no two entries from the same IP address were allowed (eg, 24 hours). Were duplicate entries avoided by preventing users with the same IP address access to the survey twice; or were duplicate database entries having the same IP address within a given period of time eliminated before analysis? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	8
Log file analysis	Indicate whether other techniques to analyze the log file for identification of multiple entries were used. If so, please describe.	N/A
Registration	In "closed" (non-open) surveys, users need to login first and it is easier to prevent duplicate entries from the same user. Describe how this was done. For example, was the survey never displayed a second time once the user had filled it in, or was the username stored together with the survey results and later eliminated? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	N/A

Handling of incomplete questionnaires	Were only completed questionnaires analyzed? Were questionnaires which terminated early (where, for example, users did not go through all questionnaire pages) also analyzed?	9,10 & Appendix 4
Questionnaires submitted with an atypical timestamp	Some investigators may measure the time people needed to fill in a questionnaire and exclude questionnaires that were submitted too soon. Specify the timeframe that was used as a cut-off point, and describe how this point was determined.	8
Statistical correction	Indicate whether any methods such as weighting of items or propensity scores have been used to adjust for the non-representative sample; if so, please describe the methods.	N/A

Appendix 2 - Electronic survey

Using technology to deliver the exercise component of cardiac rehabilitation

Start of Block: Default Question Block

Background Information Cardiac Rehabilitation is a vital treatment for patients recovering from a cardiac event. Exercise is a core component of a comprehensive cardiac rehabilitation programme, however, the outbreak of Covid-19 has meant that patients in many countries can no longer attend assessments and exercise classes in person. As a consequence, healthcare services have had to adopt new ways of working to ensure that their patients continue to receive cardiac rehabilitation services. Anecdotal evidence suggests that some cardiac rehabilitation services have begun using technology to deliver their assessments, physical activity advice, and/or exercise programmes remotely. The Covid-19 outbreak may therefore represent a step-change in services capacity to use the technology when the disease is brought under control. This may provide an opportunity to increase participation in cardiac rehabilitation among those who are unable or unwilling to travel to centre-based cardiac rehabilitation. This brief survey is designed to help the British Association for Cardiovascular Prevention and Rehabilitation understand if, or how, technology is being used to deliver the exercise component of cardiac rehabilitation. It will also capture professional experiences of using technology to deliver exercise-based cardiac rehabilitation and obtain an estimate of the patient demographic that are engaging with alternative delivery methods of cardiac rehabilitation.

Page Break

Thank you for taking the time to complete our brief survey. It should take approximately 10 minutes to complete.We have asked you to complete this survey because you are involved in the delivery of exercise-based cardiac rehabilitation and we want to understand how your practice has changed in relation to the COVID-19 outbreak. By proceeding to the next page of the survey you are providing consent to take part in the study. Only information that is essential to answer our research question will be collected. Any information collected will be helpful, and will be processed in accordance with the General Data Protection Regulation (2018). If you would like to withdraw from the study, just exit the web page. We will keep the responses you have provide even if you don't complete the whole survey. If you would like any information about data protection or the study, please contact: Dr Simon Nichols Advanced Wellbeing Research Centre Collegiate Hall Collegiate Crescent Sheffield Hallam University S10 2BP s.j.nichols@shu.ac.uk

○ Next page (1)

Page Break

Screening Q Have you previously completed this questionnaire?

- ○ Yes (1)
- ○ No (2)

Q1 Which phase of cardiac rehabilitation do you work in: (please tick the phase which you spend most of your time)

- ○ Phase I (1)
- ○ Phase II (2)
- ○ Phase III (3)
- ○ Phase IV (4)

Q2 Which country do you work in?

- ○ England (1)
- ○ Northern Ireland (2)
- ○ Scotland (3)
- ○ Wales (4)
- ○ Non-UK (please state) (5) _____

Page Break

Q3 Have you continued to provide exercise-based cardiac rehabilitation services during the COVID-19 outbreak?

- Yes – We are able to see as many patients as we did before the COVID-19 outbreak (1)
- Yes – But we aren't able to see as many patients as we did before the COVID-19 outbreak (2)
- No – All services have been cancelled/there are no staff to run our programmes (3)

Q4 Since the COVID-19 outbreak, has your service found that:

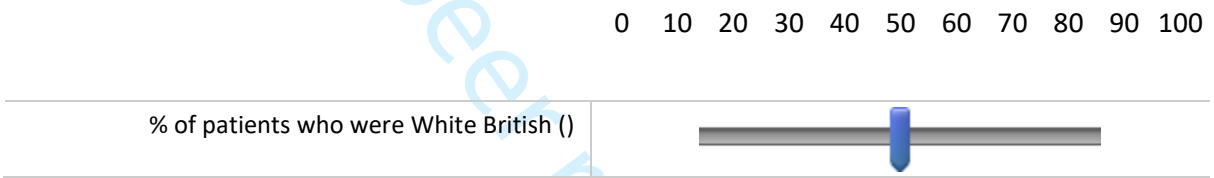
- The same number of patients are accessing exercise-based cardiac rehabilitation (1)
- Fewer patients are accessing exercise-based cardiac rehabilitation (2)
- No patients are accessing exercise-based cardiac rehabilitation (3)

Page Break

Q5 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to ethnicity?

- [ ] No - my patient population is less diverse (1)
- [ ] Yes - my patient population is as diverse as normal (2)
- [ ] No - my patient population is more diverse (3)

Q6 Only answer this question if you are a UK centre. Approximately what percentage of the patients you saw in the last 7 days were White British?



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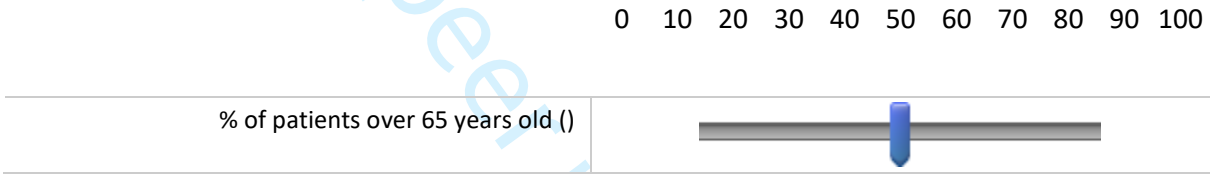
Q7 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to age?

- ○ No - my patient population is younger (1)
- ○ Yes - the age group of my patients is similar to normal (2)
- ○ No - my patient population is older (3)

Q8 Approximately what percentage of the patients you saw in the last 7 days were over 65 years old?



Page Break

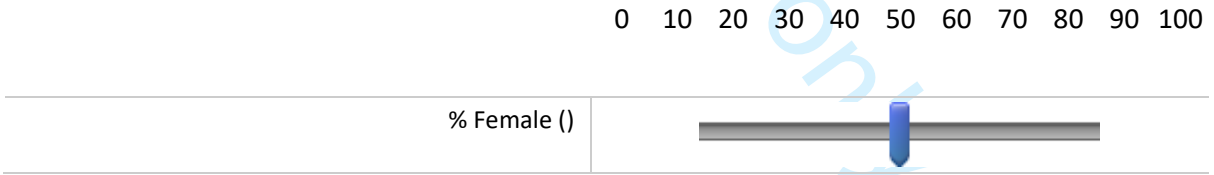
Q9 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to female participation?

- ○ No - the proportion of female participants is smaller (1)
- ○ Yes - the proportion of female participants is the same (2)
- ○ No -the proportion of female participants is larger (3)

Q10 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to male participation?

- ○ No - the proportion of male participants is smaller (1)
- ○ Yes - the proportion of male participants is the same (2)
- ○ No - the proportion of male participants is larger (3)

Q11 Approximately what percentage of the patients you saw in the last 7 days were female?



Page Break

Q12 Are you using any of the following technology to deliver a cardiac rehabilitation exercise assessment? (tick all that apply)

- ☐ Paper/postal services (1)
- ☐ Telephone (2)
- ☐ Text messaging (3)
- ☐ E-mail (4)
- ☐ Recorded video e.g. YouTube (5)
- ☐ Live video conferencing e.g. Zoom, Skype, Microsoft Teams, Facebook (6)
- ☐ Other (please state) (7) _____

Q13 How are you assessing functional capacity during your assessment? (tick all that apply)

- ☐ I am not assessing functional capacity (1)
- ☐ Self-reported fitness (2)
- ☐ Duke Activity Status Index/Other questionnaire (3)
- ☐ Step count from patients own physical activity tracker (4)
- ☐ Remotely supervised exercise test (please state which test) (5)
_____
- ☐ Other (please state) (6) _____

Q14 Are you using any of the following technology to deliver the physical activity/exercise component of cardiac rehabilitation? (tick all that apply)

- [ ] Paper/postal services (1)
- [ ] Telephone (2)
- [ ] Text messaging (3)
- [ ] E-mail (4)
- [ ] Recorded video e.g. YouTube (5)
- [ ] Live video conferencing e.g. Zoom, Skype, Microsoft Teams, Facebook (6)
- [ ] Other (please state) (7) _____

Page Break

Q15 Did you use this technology before the COVID-19 restrictions?

- ○ Yes (1)
- ○ No (2)

Q16 On approximately what date did you start using this technology?

_____

Q17 If you used remote technology before the COVID-19 restrictions, have you found that:

- ○ The same number of patients are accessing exercise-based cardiac rehabilitation using technology (1)
- ○ Fewer patients are accessing exercise-based cardiac rehabilitation using technology (2)
- ○ No patients are accessing exercise-based cardiac rehabilitation using technology (3)

Page Break

Q18 Are you able to use technology to deliver exercise-based cardiac rehabilitation to: (tick all that apply)

- [ ] Low risk patients (1)
- [ ] Moderate risk patients (2)
- [ ] High risk patients (3)

Q19 I am able to offer physical activity recommendations to patients that have not had an assessment in person? (i.e. in the same room as the assessor)

- ○ Yes (1)
- ○ No (2)

Q20 I am able to offer an exercise prescription to patients that have not had an assessment in person? (i.e. in the same room as the assessor)

- ○ Yes (1)
- ○ No (2)

*

Q21 Can you briefly describe what kind of physical activity recommendations you are making and/or exercises you are prescribing?

Examples may include chair-based exercise, resistance bands, walking, running on the spot and body weight exercises.

_____

_____

Page Break

Q22 How many supervised physical activity/exercise training sessions can a patient attend, each week?

_____

Q23 Are the physical activity/exercise sessions you are supervising: (tick all that apply)

- ☐ Group exercise (1)
- ☐ One-on-one (2)

*

Q24 How long is each supervised physical activity/exercise session? Please provide your answer in minutes.

_____

Page Break

Q25 How many unsupervised physical activity/exercise training sessions are you prescribing for a patient, each week?

_____

Q26 How long is each unsupervised physical activity/exercise session? Please provide your answer in minutes.

_____

Page Break

Q27 What intensity range do you recommend/prescribe? (tick all that apply)

- [ ] Low (e.g. RPE 11) (1)
- [ ] Moderate (e.g. RPE 13) (2)
- [ ] High (e.g. RPE 15) (3)

Q28 Is this intensity: (Tick one option only)

- ○ Lower than normal (1)
- ○ The same as normal (2)
- ○ Higher than normal (3)

Page Break

29 Do you think that the programmes you are providing are: (Tick one option only)

- ○ More effective than normal (1)
- ○ As effective as normal (2)
- ○ Less effective than normal (3)

Page Break

Q30 What barriers have you encountered when using technology to deliver cardiac rehabilitation? (tick all that apply)

- ☐ No barriers (1)
- ☐ Patients have no internet connection (2)
- ☐ Patients do not have access to computers/tablets/smart phone (3)
- ☐ Patients are not confident in using technology (4)
- ☐ Patients are concerned about personal safety (5)
- ☐ Patient lack of interest in receiving services using technology (6)
- ☐ My Trust/Health Board /employer do not support the delivery of health services using technology (7)
- ☐ Internet security and patient confidentiality concerns (8)
- ☐ Professionals are not confident in delivering services using technology (9)
- ☐ Professionals are concerned about patient safety (10)
- ☐ Other (please specify) (11) _____

Page Break

Q31 How many adverse events resulting in minor injury have been reported since you have started delivering cardiac rehabilitation remotely? Please only report incidents that are related to exercise-based cardiac rehabilitation.

_____

Page Break

Q32 How many adverse events resulting in life changing injury have been reported since you have started delivering cardiac rehabilitation remotely? Please only report incidents that are related to exercise-based cardiac rehabilitation.

_____

Page Break

Q33 How many adverse events resulting in death have been reported since you have started delivering cardiac rehabilitation remotely? Please only report incidents that are related to exercise-based cardiac rehabilitation.

_____

Page Break

Q34 Do you think that the way you are using technology now should be an option for patients in your future standard practice?

- ○ Yes (1)
- ○ No (2)

Page Break

*

Q35 Is there anything else you would like to tell us about your experience or approaches to delivering exercise-based cardiac rehabilitation using remote technology? (500 characters max)

_____

_____

_____

_____

_____

End of Block: Default Question Block

Appendix 3 - Recruitment material

Appendix 3a - E-mail to BACPR members on 2nd and 25th of June 2020

BACPR Survey - Use of remote technology to deliver the exercise component of cardiac rehabilitation.

Dear Member,

The outbreak of Covid-19 has meant that patients in many countries can no longer attend assessments and exercise classes in person. As a consequence, many healthcare services have had to adopt new ways of working to ensure that their patients continue to receive cardiac rehabilitation services. Anecdotal evidence suggests that some cardiac rehabilitation services have begun to use technology to deliver their assessments, physical activity advice, and/or exercise programmes, remotely. The Covid-19 outbreak may therefore represent a step-change in services capacity to use the technology when the disease is brought under control. This may provide an opportunity to increase participation in cardiac rehabilitation among those who are unable or unwilling to travel to centre-based cardiac rehabilitation, in the long-term.

To help improve the provision of cardiac rehabilitation in the future, we would be extremely grateful if you could take 10 minutes to complete a brief survey which will help the British Association for Cardiovascular Prevention and Rehabilitation understand if, or how, technology is being used to deliver the exercise component of cardiac rehabilitation. It will also capture your professional experiences of using technology to deliver exercise-based cardiac rehabilitation and obtain an estimate of the patient demographic that are engaging with alternative delivery methods of cardiac rehabilitation. The findings of the study will be disseminated through the BACPR as well as conferences, scientific publications, and if appropriate, training courses.

The survey can be completed on a desktop computer or a smart phone, and will take approximately 10 minutes. To proceed to the survey, click here.

Thank you for taking the time to consider taking part in this study.

Best wishes

Dr Simon Nichols

Simon Nichols

BACPR Scientific Chair

British Association for Cardiovascular Prevention & Rehabilitation

c/o BCS, 9 Fitzroy Square,

London

W1T 5HW

www.bacpr.com

Appendix 3b - Example Twitter advert posted on Twitter by the study authors on June 3rd 2020

RT #COVID19 is an unprecedented challenge to #cardiacrehab Please tell us if/how you are using technology to deliver the exercise component of CR by completing this 10 minute survey Down pointing backhand index https://shusls.eu.qualtrics.com/jfe/form/SV_eEgClDLGhsAE7Fr?Q_CHL=social&Q_SocialSource=twitter @bacpr @A_ODoherty @susandawkes @aynsleycowie @drtom_butler @SHU_PAWPH

Example advert posted by the BACPR Exercise Instructor Network on their Facebook page, on 8th June 2020

Appendix 3c - Calling all BACPR Members please check your email inboxes!!

We would greatly appreciate your help in completing our survey regarding the use of remote technology to deliver the exercise component of Cardiac Rehab. The findings of this study will be disseminated through the BACPR, conferences & scientific publications.

Question	Results reported in Manuscript	Phase I Responses	Phase II Responses	Phase III Responses	Phase IV Responses	Total Responses
Q1 Which phase of cardiac rehabilitation do you work in: (please tick the phase which you spend most of your time)	Yes – Page 7	14	29	164	123	330
Q2) Which country do you work in?	Yes – Page 7	14	29	164	123	330
Q3) Have you continued to provide exercise-based cardiac rehabilitation services during the COVID-19 outbreak?	Yes – Page 8 & Table 1	14	29	164	123	330
The following questions are applicable to a maximum of 167 respondents due to 163 programmes stating that their service had been suspended						
Q4 Since the COVID-19 outbreak, has your service found that: -The same number of patients are accessing exercise-based cardiac rehabilitation -Fewer patients are accessing exercise-based cardiac rehabilitation -No patients are accessing exercise-based cardiac rehabilitation	Yes – Page 8 & Table 1	8	17	102	34	161
Q5 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to ethnicity?	Yes – Page 8 & Table 1	7	16	95	33	151
Q6 Only answer this question if you are a UK centre. Approximately what percentage of the patients you saw in the last 7 days were White British?	Yes – Page 8 & Table 1	5	5	83	30	123
Q7 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to age?	Yes – Page 8 & Table 1	7	15	92	32	146
Q8 Approximately what percentage of the patients you saw in the last 7 days were over 65 years old?	Yes – Page 8 & Table 1	7	13	88	31	139
Q9 Are the patients you are currently treating representative of the	Yes – Page 8 & Table 1	6	15	85	29	135

patients you would treat under normal circumstances, with respect to female participation?						
Q10 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to male participation?	Yes – Table 1	6	15	85	29	135
Q11 Approximately what percentage of the patients you saw in the last 7 days were female?	Yes – Page 8 & Table 1	6	14	77	28	125
Q12 Are you using any of the following technology to deliver a cardiac rehabilitation exercise assessment?	Yes – Page 9 & Figure 2	6	14	84	29	133
Q13 How are you assessing functional capacity during your assessment?	Yes – Page 9	6	14	84	29	133
Q14 Are you using any of the following technology to deliver the physical activity/exercise component of cardiac rehabilitation?	Yes – Page 11 & Figure 3	6	14	84	29	133
Q15 Did you use this technology before the COVID-19 restrictions?	Yes - Page 8	6	14	81	27	128
Date of technology adoption	Yes – Page 8	5	14	80	27	126
Q17 If you used remote technology before the COVID-19 restrictions, have you found that: -The same number of patients are accessing exercise-based cardiac rehabilitation using technology -Fewer patients are accessing exercise-based cardiac rehabilitation using technology -No patients are accessing exercise-based cardiac rehabilitation using technology	No	6	7	44	8	65

Q18 Are you able to use technology to deliver exercise-based cardiac rehabilitation to: -Low risk patients -Moderate risk patients -High risk patients	Yes – Page 11	6	12	79	26	123
Q19 I am able to offer physical activity recommendations to patients that have not had an assessment in person? (i.e. in the same room as the assessor)	Yes – Page 11	6	12	79	26	123
Q20 I am able to offer an exercise prescription to patients that have not had an assessment in person? (i.e. in the same room as the assessor)	Yes – Page 11	6	12	79	26	123
Q21 Can you briefly describe what kind of physical activity recommendations you are making and/or exercises you are prescribing?	No	6	7	44	8	65
Q22 How many supervised physical activity/exercise training sessions can a patient attend, each week?	No	6	11	72	26	115
Q23 Are the physical activity/exercise sessions you are supervising: Group exercise One-on-one	No	5	8	24	24	61
Q24 How long is each supervised physical activity/exercise session? Please provide your answer in minutes.	No	5	8	25	26	64
Q25 How many unsupervised physical activity/exercise training sessions are you prescribing for a patient, each week?	No	5	10	70	24	109

Q26 How long is each unsupervised physical activity/exercise session? Please provide your answer in minutes.	No	4	9	56	12	81
Q27 What intensity range do you recommend/prescribe?	No	6	9	70	24	109
Q28 Is this intensity	No	6	9	70	24	109
Q29 Do you think that the programmes you are providing are:	No	6	9	70	24	109
Q30 What barriers have you encountered when using technology to deliver cardiac rehabilitation? (tick all that apply)	Yes – Page 11 & Table 2	6	9	68	24	107
Q31 How many adverse events resulting in minor injury have been reported since you have started delivering cardiac rehabilitation remotely?	Yes – Page 11	6	9	68	24	107
Q32 How many adverse events resulting in life changing injury have been reported since you have started delivering cardiac rehabilitation remotely?	Yes – Page 11	6	9	68	24	107
Q33 How many adverse events resulting in death have been reported since you have started delivering cardiac rehabilitation remotely?	Yes – Page 11	6	9	68	24	107
Q34 Do you think that the way you are using technology now should be an option for patients in your future standard practice?	Yes – Page 15	6	8	68	24	106
Q35 Is there anything else you would like to tell us about your experience or approaches to delivering exercise-based cardiac rehabilitation using remote technology?	Yes – Qualitative synthesis; Pages 12-15	1	4	39	13	57

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How has technology been used to deliver cardiac rehabilitation during the COVID-19 pandemic? An international cross-sectional survey of healthcare professionals conducted by the BACPR

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Abstract

Objective: To investigate whether exercise-based cardiac rehabilitation services continued during the COVID-19 pandemic, and investigate how technology has been used to deliver home-based cardiac rehabilitation.

Design: A mixed methods survey, including questions about exercise-based cardiac rehabilitation service provision, programme diversity, patient complexity, technology use, barriers to using technology, and safety.

Setting: International survey of exercise-based cardiac rehabilitation programmes

Participants: Healthcare professionals working in exercise-based cardiac rehabilitation programmes, worldwide.

Main outcome measures: The proportion of programmes that continued providing exercise-based cardiac rehabilitation, and which technologies had been used to deliver home-based cardiac rehabilitation.

Results: Three-hundred and thirty eligible responses were received; 89.7% were from the UK. Approximately half (49.3%) of respondents reported that CR programmes were suspended due to COVID-19. Of programmes that continued; 25.8% used technology before the COVID-19 pandemic. Programmes typically started using technology within 19 days of COVID-19 becoming a pandemic. 48.8% did not provide CR to high-risk patients, telephone was most commonly used to deliver CR, and some centres used sophisticated technology such as teleconferencing.

Conclusions: The rapid adoption of technology into standard practice is promising and may improve accessibility, or participation, in exercise-based CR beyond COVID-19. However, the exclusion of certain patient groups and programme suspension, could worsen clinical symptoms and wellbeing, and increase hospital admissions. Refinement of current practices, with a focus on improving

inclusivity and addressing safety concerns around exercise support to high-risk patients, may be needed.

Abstract: 233 Words

Key words: Cardiac rehabilitation, COVID-19, Telehealth, Exercise training,

Article Summary

Strengths and limitations of this study

- This is the first international reporting on the effect that COVID-19 restrictions have had on exercise-based cardiac rehabilitation.
- We report data from *n*=330 cardiac rehabilitation programmes around the world, although the majority of data were from the United Kingdom.
- Our mixed methods survey enabled us to investigate how technology has been used to deliver exercise-based cardiac rehabilitation, as well the barriers to using technology.
- Respondents were only able to complete the survey once, but we could have received more than one response from professionals working in a single cardiac rehabilitation programme.
- Our data could be used to inform future research agendas, international healthcare policy, and local healthcare decision making.

Financial support

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors

Competing interests

SN has received funding from Research England, via the Advanced Wellbeing Research Centre Accelerator, to evaluate the effect of a technology platform for cardiac rehabilitation developed by Aseptika Ltd. SN, AFO, AC, and HH have received funding from AstraZeneca to investigate factors

influencing uptake on to cardiac rehabilitation. SN, SD, TB, and AC are members of the BACPR Council. SD received funding from the Burdett Trust to investigate uptake on to exercise referral schemes. SD participated in cardiovascular prevention advisory board for AstraZeneca. SH is Executive Director of the British Association for Cardiovascular Prevention and Rehabilitation (BACPR). PB has received funding from the National Institute of Health for Cardiac Rehabilitation-related research. PB has also received consultation fees and honoraria from Merck, Ingelheim Boehringer, Corvia Medical, and Boston Scientific.

Introduction

Cardiac rehabilitation (CR) is a comprehensive programme of secondary prevention interventions for patients with heart disease, encompassing support for psychosocial health, medical risk management and cardiovascular risk factor modification, including exercise training [1]. Exercise-based CR reduces cardiovascular deaths and recurrent myocardial infarction within 10 years, hospital admissions within 2 years, and improves health-related quality of life [2-5]. Despite these benefits, only 49% (n=141,648) of eligible United Kingdom (UK) patients enrolled on to a CR programme between 2012 and 2015 [6]. Increasing uptake to 65% could lead to 21,000 fewer hospital admissions and 8,500 fewer deaths over 10 years [7]. In response, NHS England set an ambitious target to increase CR uptake to 85% by 2029 [8].

COVID-19 is spread by a highly contagious virus. As of September 2020, it has infected 26,121,999 and has killed 864,618 people worldwide [9]. The rapid spread of COVID-19 infections resulted in governments imposing restrictions on face-to-face human contact [10]. Numerous 'non-essential' healthcare services were suspended and patient attendance to continuing services has decreased due to fear of contracting COVID-19 [11, 12]. The COVID-19 pandemic may therefore undermine efforts to increase uptake to exercise-based CR.

Before COVID-19, expanding the availability of home-based programmes was recommended to increase participation in exercise-based CR [13]. This is partly due to a lack of capacity within existing face-to-face services [14]. Yet, in 2019, 8.8% of UK CR patients participated in home-based programmes [15]. The recent suspension of face-to-face healthcare services may have led to programmes rapidly adopting home-based, technology facilitated services. Data from urgent and non-urgent care centres in the United States of America (USA) reported that teleconferencing consultations increased from 82 on March 4th 2020, to 1336 on 19th March 2020 [16]. If a similar rate of technology adoption occurred in CR, this could have helped to maintain patient participation. These methods could also be adopted in to future standard practice to increase accessibility and subsequent uptake onto CR programmes.

The aim of this mixed-methods survey, conducted in collaboration with the British Association for Cardiovascular Prevention and Rehabilitation (BACPR), was to investigate whether exercise-based CR services continued during the COVID-19 pandemic. We also evaluated whether technology was used to deliver exercise-based CR, and the professional experiences of this technology, during the COVID-19 pandemic.

Materials and Methods

Survey development

The methods and results are reported in conjunction with the Checklist for Reporting Results of Internet E-surveys (CHERRIES; Appendix 1) [17]. This voluntary, cross-sectional, international, open survey, targeted at a convenience sample of healthcare professionals in exercise-based CR, was developed by SN and AFO. The broad topic of questions, relating to the COVID-19 pandemic, were:

1. If and how CR services were provided.
2. The demographics and medical complexity of patients accessing CR services.
3. How technology was used to undertake patient assessments and deliver the exercise component of CR.
4. The barriers encountered when using technology to deliver the exercise component of CR.

The survey was reviewed by the members of the BACPR elected Council prior to ethical approval, and amended accordingly. The BACPR council includes physicians, nurses, physiotherapists, exercise physiologists, exercise instructors, psychologists, dietitians, and occupational therapists. The resulting 35-item questionnaire was uploaded to the Qualtrics^{XM} online survey platform (Provo, Utah, USA). Qualtrics has ISO/IEC 27001 security certification. The automated database was password protected and stored on secure Qualtrics and Sheffield Hallam University servers. The survey was presented

across 21 pages, including background information and consent. There were 22 tick box items (19 mandatory), seven mandatory numerical responses, three non-mandatory sliding bar responses, two non-mandatory free-text responses, and one mandatory date entry response. Four questions also permitted free-text responses under the option 'other'. Response validation was used on all questions, where appropriate. Survey progress was displayed on each page. Participants did not have a completeness check/review option at the end of the survey. Participants were only able to visit the website once from the same IP address, and they had seven days to complete the survey once started. The functionality of the survey was tested by SN, AOD, SD, SH, and AC. The final version of the online survey (Appendix 2), was given institutional ethical approval by Sheffield Hallam University (ID: ER24303491), on the 29th May 2020. All participants provided informed consent, and all study procedures were carried out following the rules of the Declaration of Helsinki of 1975 (https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/), revised in 2013.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Survey dissemination

On 2nd June 2020, a recruitment e-mail was sent to BACPR members; 746 healthcare professionals and academics working in CR. This was repeated on June 25th 2020. The survey was also promoted on social media platforms (Appendix 3). A link to the survey *was not* posted on any website. The survey closed at 12pm on 31st July 2020. There were no incentives offered for participation.

Quantitative data analysis

Categorical data are reported as the number of responses, expressed as a percentage (%) of the respondents to each question. Continuous data are reported as median, with minimum and maximum values. Responses were reported for the full cohort, and by the Phase of CR that the respondents worked in. Phase I was defined as the inpatient stage, Phase II as the early discharge phase, Phase III as a clinically supervised outpatient programme, and Phase IV as long-term physical activity maintenance. The number of responses to each question varied and are detailed in Tables 1 and 2, and Appendix 4. Tests of statistical significance were not conducted.

Qualitative Data analysis

Free text answers were exported into NVivo 11 software for thematic analysis. Answers were coded inductively. The resulting coding framework was then reviewed to identify patterns and themes in the data. Similar codes were grouped to form lower order themes, which were then grouped into higher order themes. Each theme was given a descriptive explanation with illustrative quotes.

Results

Responses

Four-hundred and seven visits to the survey site were recorded. Seventy-seven (18.9%) did not progress past the study information and consent page (81.1% participation rate). Three-hundred and thirty responses were analysed, 296 (89.7%) were from the UK. The remaining responses were from Japan (*n*=8; 2.4%), Australia (*n*=4*;* 1.2%), the USA (*n*=4*;* 1.2%), Republic of Ireland (*n*=4*;* 1.2%), Gibraltar (*n*=2*;* 0.6%), India (*n*=2*;* 0.6%), South Africa (*n*=2*;* 0.6%), Spain (*n*=2*;* 0.6%), the Bailiwick of Guernsey (*n*=1*;* 0.3%), Canada (*n*=1*;* 0.3%), the Isle of Man (*n*=1*;* 0.3%), and Kuwait *n*=1*;* (0.3%).

Service provision during COVID-19

At the time of responding, 163 (49.3%) CR programmes had been suspended due to COVID-19 (Table 1). The proportion of UK (*n*=147*;* 49.7%) and non-UK (*n*=16; 47.1%) services that had been suspended were similar. Phase IV programmes were most likely to have suspended all activities (*n*=89; 72.4%; Table 1). The remaining questions in the survey were applicable to a maximum of 167 respondents. The number of responses to each question can be seen Table 1 and Appendix 4.

Following COVID-19 restrictions, 32 (19.9%) programmes reported that the same volume of patients were choosing to access their service (Table 1). Most programmes reported that either fewer patients (*n*=111; 68.9%), or no patients (*n*=18; 11.2%) were choosing to access their service (Table 1). Programmes believed that patients enrolling in CR were either as demographically as diverse' (*n*=122; 80.8%), or more diverse, than normal (*n*=7; 4.6%; Table 1). UK CR programmes also estimated that 90.4% (0.0 to 100.0%) of patients seen in the last seven days were 'White British'. Most CR programmes (92.5%) reported that the age of participants was similar to normal, with 70% (0.0 to 100.0%) of patients enrolling in CR >65 years of age (Table 1). Programmes also reported that the sex of patients participating in CR was proportionally similar to normal. Female participation in CR was estimated at 30% (0.0 to 80%; Table 1).

Technology adoption

Figure 1 shows the increase in adoption of technology over time. The earliest date that a programme reported using technology was the 10th January 2010. The latest was the 20th June 2020. Thirty-three (25.8%) used technology to deliver exercise-based CR before COVID-19 was declared a pandemic by the World Health Organisation (WHO) [18]. The median date of technology adoption was 30th March 2020. There were notable increases in technology adoption, the first coincided with the release of the UK's NHS long-term plan [8]. The second, more rapid increase, coincides with COVID-19 pandemic [18].

Technology use in patient assessment

The most commonly used technology was telephone (*n*=113; 85.0%; Figure 2). 24.1% (*n*=32) of programmes reported that they were not assessing or estimating functional capacity. Practitioners mostly relied on patient self-reported fitness to estimate functional capacity (*n*=92; 69.2%). Some programmes estimated functional capacity by using a questionnaire (26.3%, *n*=35), or the patient's own physical activity tracker (21.1%, *n*=28). One Phase I (16.7%), two phase II (14.3%), and four Phase IV CR programmes (13.8%) remotely supervised exercise testing (Figure 2).

Table 1 – Provision of cardiac rehabilitation services during the COVID-19 pandemic, displayed as number (%)

	All	Phase I	Phase II	Phase III	Phase IV
Service status	(*n*=330)	(*n=14)*	(*n*=29)	(*n*=164)	(*n*=123)
Services able to see as many patients as usual	44 (13.3)	2 (14.3)	6 (20.7)	30 (18.3)	6 (4.9)
Service able to see fewer patients	123 (37.3)	6 (42.9)	12 (41.4)	77 (47.0)	28 (22.8)
Service suspended (%)	163 (49.4)	7 (42.9)	11 (37.9)	57 (34.8)	89 (72.4)
Patients accessing cardiac rehabilitation	(*n*=161)	(*n=8)*	(*n*=17)	(*n*=102)	(*n*=34)
No patients are accessing the service	18 (11.2)	2 (25.0)	3 (17.6)	9 (8.8)	4 (11.8)
Fewer patients are accessing the service	111 (68.9)	5 (62.5)	13 (76.5)	65 (63.7)	28 (82.4)
Same number of patients are accessing the service	32 (19.9)	1 (12.5)	1 (5.9)	28 (27.5)	2 (5.9)
Diversity of cardiac rehabilitation	(*n*=151)	(*n=7)*	(*n*=16)	(*n*=95)	(*n*=33)
Patient population is less diverse than before COVID-19	22 (14.6)	3 (42.9)	1 (6.25)	13 (13.7)	5 (15.2)
Patient population is as diverse as it was before COVID-19	122 (80.8)	4 (57.1)	15 (93.8)	78 (82.1)	25 (75.8)
Patient population is more diverse than before COVID-19	7 (4.6)	0 (0.0)	0 (0.0)	4 (4.2)	3 (9.1)
Patient population is younger than before COVID-19	6 (4.1)	0 (0.0)	2 (13.3)	2 (2.2)	2 (6.3)
Patient population is similar to what is was before COVID-19	135 (92.5)	5 (71.4)	12 (80.0)	89 (96.7)	29 (90.6)
Patient population is older than before COVID-19	5 (3.4)	2 (28.6)	1 (6.7)	1 (1.1)	1 (3.1)
Estimated percentage of patients in the last 7 days that were >65 years?	70.0 (0.0 to 100.0)	75.0 (60.0 to 85.0)	67.0 (38.0 to 100.0)	64.5 (0.0 to 100.0)	80.0 (0.0 to 1000.0)
Proportion of female participation is smaller	11 (0.8)	1 (16.7)	0 (0.0)	8 (9.4)	2 (6.9)
Proportion of female participation is the same	113 (83.7)	4 (66.7)	14 (93.3)	69 (81.2)	26 (89.7)
Proportion of female participation is larger	11 (0.8)	1 (16.7)	1 (6.7)	8 (9.4)	1 (3.4)
Proportion of male participation is smaller	6 (4.4)	1 (16.7)	1 (6.7)	2 (2.4)	2 (7.0)
Proportion of male participation is the same	123 (91.1)	4 (66.7)	14 (93.3)	79 (92.9)	26 (89.7)
Proportion of male participation is larger	6 (4.4)	1 (16.7)	0 (0.0)	4 (4.7)	1 (3.4)
Estimated percentage of patients in the last 7 days were female?	30.0 (0.0 to 80.0)	40.0 (10.0 to 70.0)	30.0 (1.0 to 57.0)	30.0 (0.0 to 80.0)	40.0 (1.0 to 73.0)

Technology use in physical activity and exercise prescription

Most services were able to provide physical activity advice (*n*=102; 82.9%). Seventy-two (58.5%) programmes also offered structured exercise training programmes. Telephone remained the most commonly used technology to facilitate the physical activity or exercise component of CR (*n*=86, 64.7%; Figure 3). Pre-recorded online videos (*n*=69; 51.9%) were also widely used, particularly among Phase III programmes (*n*=54; 64.3%; Figure 3). Most CR services were able to provide physical activity or structured exercise training to patients at low (*n*=117; 95.1%) and moderate risk (*n*=109; 88.6%) of exercise-induced cardiac events. Half (51.2%; *n*=63) were able to offer services to patients at high-risk of exercise-induced cardiac events. Three (2.8%) programmes reported one adverse event resulting in minor injury whilst using technology to deliver the exercise component of CR (three events in total). There were no reports of life changing injury, or death.

Barriers to using technology

The number of responses to each question about barriers to using technology is shown in Table 2. Respondents were asked to state *any* barriers that they encountered when using technology. Only two (1.9%) programmes reported 'no barriers' (Table 2). Most (*n*=93; 86.9%) encountered a "lack of patient confidence" with technology (Table 2). Qualitative analysis of the barriers to using technology fell into two categories; logistical and organisational barriers, and patient-related barriers. Logistical and organisational barriers were largely a result of healthcare organisations being unprepared, and not familiar with using online healthcare delivery. Onerous governance processes or delayed access to the necessary IT equipment were also described. Patient-related barriers were associated with communication (either language or understanding), and concerns that patients were either over-reporting their activity or not following advice provided.

Practitioner experiences

Qualitative analysis of free text answers to the final question allowing "Any other comments" resulted in the identification of three higher order themes; i) impact on patient experience; ii) challenges for staff and iii) implications for future delivery.

i) Impact on patient experience

Survey respondents varied in their views about the impact on patient engagement and experience. Technology was acknowledged as a valuable means of connecting patients with CR staff, but a small number of respondents also highlighted that it was harder to establish a rapport this way. One participant reported a decline in patients' fitness outcomes whilst another claimed that patients exercised harder at home without peers to distract them. More commonly, participants reported that regardless of the perceived benefits of remote delivery, it was difficult to replicate the social benefits associated with group exercise delivery:

> *"The lack of contact with other patients means the patients miss out on the social and emotional support from each other."*

Table 2 –Barriers to using technology in exercise-based cardiac rehabilitation displayed as number (%)

Barriers to using technology	All (*n*=107)	Phase I (*n=6)*	Phase II (*n*=9)	Phase III (*n*=68)	Phase IV (*n*=24)
Lack of patient confidence	93 (86.9)	2 (33.3)	8 (88.9)	60 (88.2)	23 (95.8)
Patients do not have access to computers/tablets/smart phone	86 (80.4)	2 (33.3)	4 (44.4)	61 (89.7)	19 (79.2)
Patients do not have an internet connection	73 (68.2)	2 (33.3)	6 (66.7)	48 (70.6)	17 (70.8)
Patients lack of interest in receiving services using technology	65 (60.7)	1 (16.7)	5 (55.6)	44 (64.7)	15 (62.5)
Professionals are concerned about patient safety	43 (40.2)	0 (0.0)	3 (33.3)	34 (50.0)	6 (25.0)
Patients are concerned about safety	32 (29.9)	2 (33.3)	3 (33.3)	21 (30.9)	6 (25.0)
Internet security and patient confidentiality concerns	27 (25.2)	1 (16.7)	4 (44.4)	18 (25)	4 (16.7)
Professionals not confident delivering service using technology	24 (22.4)	0 (0.0)	2 (22.2)	19 (27.9)	3 (12.5)
Trust/Health Board do not support the delivery of health services using technology	16 (15.0)	1 (16.7)	0 (0.0)	14 (20.6)	1 (4.2)
No barriers	2 (1.9)	1 (11.1)	0 (0.0)	1 (1.5)	0 (0.0)

ii) Challenges for professionals

Survey participants cited a range of challenges to adoption of technology, including the limitations of existing platforms, such as smart device applications for CR. These were described as lacking patient-centred or motivational content and time-consuming to use. Participants reported further difficulties associated with COVID-19 related staff redeployment or illness, and reiterated barriers such as lack of access to technology and organisational delays caused by IT and governance restrictions.

A large number of comments described concerns relating to practitioners' inability to observe patients, limiting safe and accurate assessment of functional capacity. This had resulted in a more cautious approach, with respondents reporting that they prescribed only gentle or low-level exercise:

> *"Our main concern has been the difficulty of not being able to complete functional capacity assessments, we have therefore recommended patients exercise at a lower level than we normally would."*

iii) Implications for future delivery

Many respondents reported optimism about continuing to incorporate technology in future CR delivery. Nevertheless, it was generally recognised that delivery should be flexible. Exercise programmes should be tailored to individual needs and risk levels and patients should be provided with a range of options for engaging with CR, including both face-to-face contact with CR staff and online/home-based exercise.

Several comments indicated opportunities for improvement in the technology available, with one participant suggesting that current formats were driven by NACR audit data requirements as opposed to patient needs. Another respondent called for further research to inform more confident remote exercise prescription:

"Still feel face to face assessment is superior for more frail patients …and for higher risk patients… Nevertheless, I am gaining more confidence in remote assessment, and would be reassured further by some research to demonstrate its safety and efficacy. I already know remote delivery has been shown to be safe and effective, but as far as I am aware this has been evidenced only when prescribed from face to face assessment."

Quantitatively, 94 (88.7%) programmes believed that technology should be available for patients in the future.

Discussion

To our knowledge, this is the first study to quantitatively document the effect that restrictions, imposed due to COVID-19, had on exercise-based CR programmes. We found that nearly half of all programmes had been suspended and that most centres reported a reduction in patient engagement with services during the COVID-19 pandemic. Practitioners reported that the age and sex of patients attending CR was similar to before the COVID-19 pandemic. Technology was rapidly adopted to deliver CR, with less sophisticated technology, such as the telephone, being most widely used. Higher risk patients were less likely to be offered remote CR using technology. Nearly all centres reported barriers to using technology to deliver CR. Finally, despite an openness to adopting technology by practitioners, there were concerns surrounding availability of, and confidence in using technology. Qualitatively, patient assessment, less opportunity for socialisation, and safety were highlighted.

Service provision

COVID-19 has resulted in many non-essential healthcare services being suspended. We have shown that this was true for half of exercise-based CR services. In 2019, 89,573 patients accessed exercise-

based CR in the UK [15], therefore a high proportion of cardiac patients may have been negatively affected by this widespread service disruption. Given that exercise-based CR improves quality of life [4, 19] and reduces hospital admissions [3], suspension of services is likely to result in worsening clinical symptoms, wellbeing, and increased hospital admissions long-term. This may place an increased burden on healthcare services in the coming months. Nevertheless, there was an increase in the use of technology in CR shortly after COVID-19 was declared a Pandemic by the WHO [18]. Comparing long-term patient outcomes from programmes that continued service provision with programmes that were unable to continue will help to determine the effectiveness of these changes.

Technology adoption and barriers

Recent editorials and reviews have suggested that COVID-19 could be a catalyst for large-scale changes in the way that CR is delivered [20, 21]. We found that most services started using technology to deliver home-based exercise-based CR within three weeks of COVID-19 being declared a pandemic by the WHO [18], only three services were providing face-to-face services. This suggests that the capacity of CR services to provide home-based rehabilitation programmes has rapidly increased. If maintained, subject to robust evidence, the potential for increased accessibility, could positively influence participation in CR when face-to-face service have resumed.

Traditional modes of communication such as telephone were most commonly used. Surprisingly few services used tele-conferencing, smart device applications and web-based systems. Healthcare professionals cited that patients often lacked confidence using equipment and/or that patients did not have the required equipment for technology use. The number and sociodemographic profile of patients for whom this was a genuine barrier is unclear. Others have reported that age may be a factor, with people aged 22-44 years most likely use tele-conferencing facilities [16], and people over 65 years being less likely to have a smart phone [22]. This could warrant further investigation to address inequalities in the accessibility of technology-based provision of CR. Meanwhile, professionals'

concern for patient safety (40.2%) and internet security (25.2%) were also likely to contribute to the low uptake of novel technology. Healthcare organisations being underprepared for the adoption of new technology may also play a role, although this was less frequently reported in quantitative analysis. 'Top-down' endorsement of technology by health Trusts, Health Boards or healthcare providers may give healthcare professionals confidence in using technology.

Participation

Participation in CR continued despite COVID-19 restrictions. However, programmes were able to offer services to fewer patients and update was reduced. Furthermore, UK programmes reported that ~90% of participants were 'White British', which is proportionately higher than recently indicated (79%) in the 2019 NACR report [15]. Future research should investigate the direct impact of COVID-19 on minority group participation in exercise-based CR, and explore how to increase their participation when it is delivered using technology. Encouragingly, programmes reported that similar proportions of males and females, and people over the age of 65 years, engaged with CR compared to pre-COVID-19 participation.

Data from our survey showed that 41.5% of programmes were unable to provide exercise-based CR to patients at high-risk of exercise-induced cardiac events. CR should be available to all eligible patients, irrespectively of risk [1]. The development and refinement of future technology-based interventions should be inclusive of all risk levels. Qualitative comments highlighted concerns about using technology to remotely deliver exercise-based CR for frail patients. Safety concerns were also a common feature in our quantitative analysis (Table 2). The wide use of 'offline' delivery modes such as telephone and pre-recorded videos identified in our survey limits the capacity to evaluate physiological information during exercise and the scope for practitioners to tailor advice to the individual. It may be perceived as unsafe for patients at high-risk of exercise-induced event, but not

for lower risk patients. Overcoming these concerns, through robust evidence, may be an important step in negating future health inequalities.

Limitations

The high UK response rate to our survey (*n*=296; 89.7%) makes it likely that our findings are representative of CR in the UK. However, the response rate from CR programmes outside of the UK was low. The generalisability of our findings to the rest of the world may therefore be limited. Additionally, we aimed to recruit healthcare professionals rather than patients. Future research should investigate patient perceptions of using technology in CR so that a more complete understanding of barriers can be reported. We also asked study participants to report on whether they perceived that certain demographics of the patients engaging with their services had changed, therefore we cannot exclude information bias. Finally, individual practitioners rather than centres were targeted to respond. Therefore, the risk of bias could have been increased by multiple practitioners from the same centre completing the survey.

Conclusions

Nearly half of all CR programmes have been suspended during COVID-19 restrictions. Technology was rapidly adopted by CR services which may increase participation beyond COVID-19. However, higher risk patients may be disadvantaged by technology use, whilst people in the UK who are 'White British' may be most likely to benefit for it. Our findings indicate a role for technology in future CR delivery. There is a need for innovation in patient-centred, interactive technological resources that also foster confidence amongst practitioners. Future research needs to investigate the longer-term adoption of technology in CR following COVID-19, and its effects on participation, patient experience and safety.

Author Statement

Conceptualization: Simon Nichols; **Methodology:** Simon Nichols, Alasdair O'Doherty, Helen Humphreys, Susan Dawkes, Aynsley Cowie, Sally Hinton; **Formal Analysis:** Simon Nichols, Alasdair O'Doherty, Helen Humphreys; **Investigation:** Simon Nichols, Alasdair O'Doherty, Helen Humphreys, Susan Dawkes, Aynsley Cowie, Sally Hinton, Peter Brubaker, Tom Butler; **Data curation:** Simon Nichols, Helen Humphreys; **Writing- Original draft preparation:** Simon Nichols; **Writing - Review & Editing:** Simon Nichols, Alasdair O'Doherty, Helen Humphreys, Susan Dawkes, Aynsley Cowie, Sally Hinton, Peter Brubaker, Tom Butler; **Visualization:** Simon Nichols**; Supervision:** Simon Nichols; **Project Administration:** Simon Nichols

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Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Data sharing

Data will be available, on reasonable request, 18 months after publication of the manuscript. Data can be requested by contacting the corresponding author, or by contacting library-research-support@shu.ac.uk.

Ethics Statement

Sheffield Hallam University Ethics Board reviewed and approved this study (ID: ER24303491). Electronic consent to participate in the survey was obtained from all participants. All study processes conform to the relevant regulations and standards.

Figure 1 – Data showing the use of technology to deliver exercise-based cardiac rehabilitation between January 2010 and June 2020. Black bars indicate how many programmes started using their chosen technology, on a given date. The grey area shows the cumulative number of cardiac rehabilitation programmes using technology.

Figure 2 – Types of technology used to undertake baseline assessments. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

Figure 3 – Types of technology used to deliver the exercise component of cardiac rehabilitation. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

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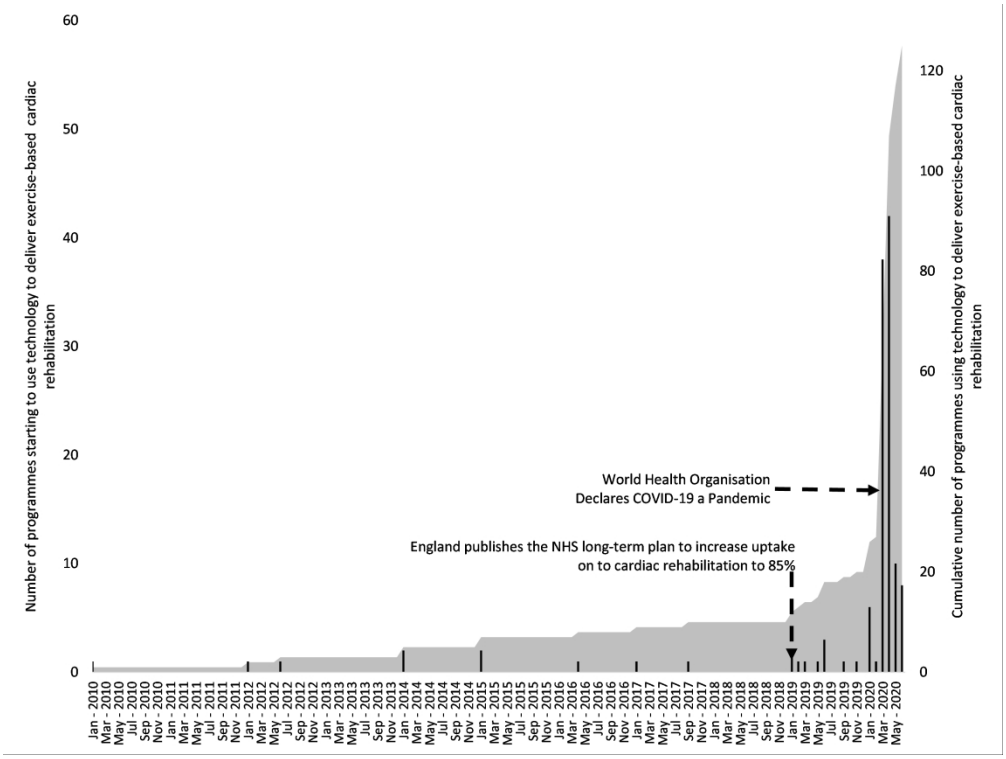

Figure 1 – Data showing the use of technology to deliver exercise-based cardiac rehabilitation between January 2010 and June 2020. Black bars indicate how many programmes started using their chosen technology, on a given date. The grey area shows the cumulative number of cardiac rehabilitation programmes using technology.

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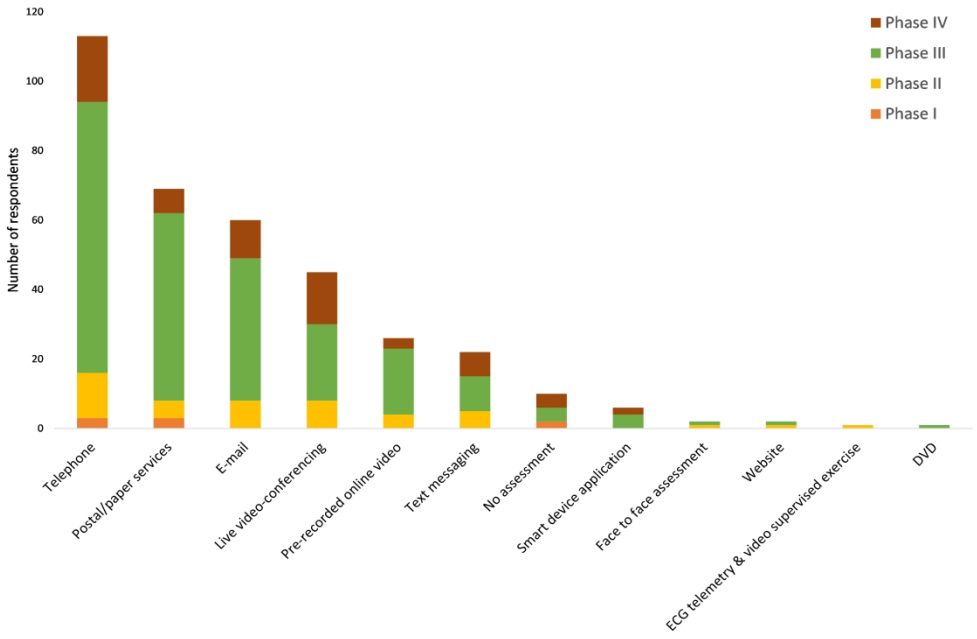


Figure 2 – Types of technology used to undertake baseline assessments. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

272x175mm (300 x 300 DPI)

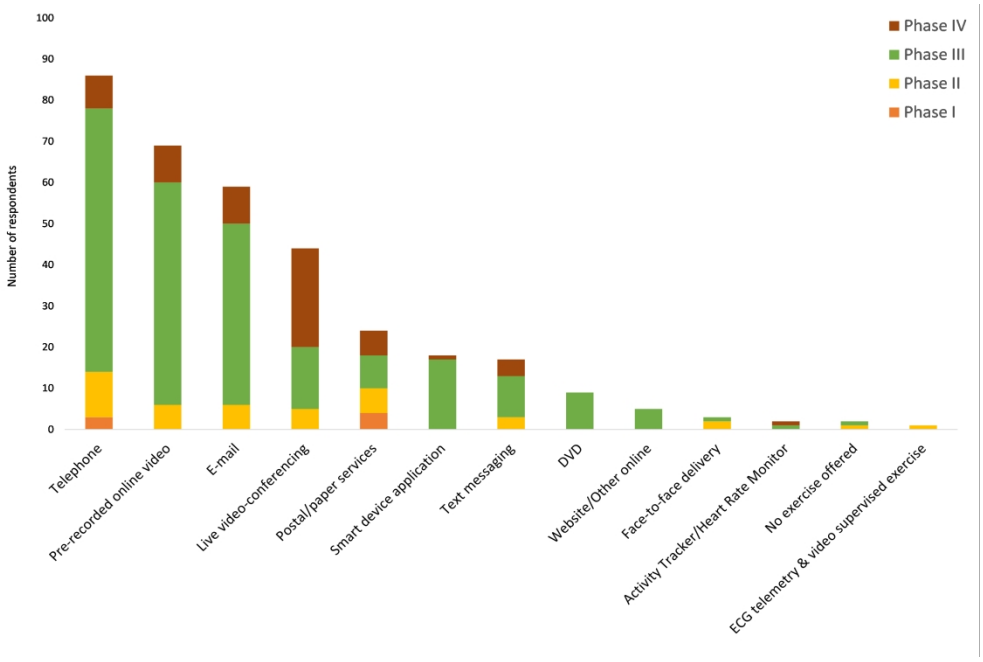


Figure 3 – Types of technology used to deliver the exercise component of cardiac rehabilitation. Orange bars indicate Phase I programmes, yellow bars indicate Phase II programmes, green lines indicate Phase III programmes, red bars indicate Phase IV programmes.

270x176mm (300 x 300 DPI)

Appendix 1 - Checklist for Reporting Results of Internet E-Surveys (CHERRIES)

Checklist Item	***Explanation***	***Page Number***
Describe survey design	Describe target population, sample frame. Is the sample a convenience sample? (In "open" surveys this is most likely.)	7
IRB approval	Mention whether the study has been approved by an IRB.	8
Informed consent	Describe the informed consent process. Where were the participants told the length of time of the survey, which data were stored and where and for how long, who the investigator was, and the purpose of the study?	Page 8 & Appendix 2
Data protection	If any personal information was collected or stored, describe what mechanisms were used to protect unauthorized access.	7
Development and testing	State how the survey was developed, including whether the usability and technical functionality of the electronic questionnaire had been tested before fielding the questionnaire.	7 & 8
Open survey versus closed survey	An "open survey" is a survey open for each visitor of a site, while a closed survey is only open to a sample which the investigator knows (password-protected survey).	7
Contact mode	Indicate whether or not the initial contact with the potential participants was made on the Internet. (Investigators may also send out questionnaires by mail and allow for Web-based data entry.)	8
Advertising the survey	How/where was the survey announced or advertised? Some examples are offline media (newspapers), or online (mailing lists – If yes, which ones?) or banner ads (Where were these banner ads posted and what did they look like?). It is important to know the wording of the announcement as it will heavily influence who chooses to participate. Ideally the survey announcement should be published as an appendix.	8 & Appendix 3
Web/E-mail	State the type of e-survey (eg, one posted on a Web site, or one sent out through e-mail). If it is an e-mail survey, were the responses entered manually into a database, or was there an automatic method for capturing responses?	8
Context	Describe the Web site (for mailing list/newsgroup) in which the survey was posted. What is the Web site about, who is visiting it, what are visitors normally looking for? Discuss to what degree the content of the Web site could pre-select the sample or influence the results. For example, a	8

	survey about vaccination on a anti-immunization Web site will have different results from a Web survey conducted on a government Web site	
Mandatory/voluntary	Was it a mandatory survey to be filled in by every visitor who wanted to enter the Web site, or was it a voluntary survey?	7
Incentives	Were any incentives offered (eg, monetary, prizes, or non-monetary incentives such as an offer to provide the survey results)?	8
Time/Date	In what timeframe were the data collected?	8
Randomization of items or questionnaires	To prevent biases items can be randomized or alternated.	N/A
Adaptive questioning	Use adaptive questioning (certain items, or only conditionally displayed based on responses to other items) to reduce number and complexity of the questions.	N/A
Number of Items	What was the number of questionnaire items per page? The number of items is an important factor for the completion rate.	7, 8 & Appendix 2
Number of screens (pages)	Over how many pages was the questionnaire distributed? The number of items is an important factor for the completion rate.	8
Completeness check	It is technically possible to do consistency or completeness checks before the questionnaire is submitted. Was this done, and if “yes”, how (usually JAVAScript)? An alternative is to check for completeness after the questionnaire has been submitted (and highlight mandatory items). If this has been done, it should be reported. All items should provide a non-response option such as “not applicable” or “rather not say”, and selection of one response option should be enforced.	8
Review step	State whether respondents were able to review and change their answers (eg, through a Back button or a Review step which displays a summary of the responses and asks the respondents if they are correct).	8
Unique site visitor	If you provide view rates or participation rates, you need to define how you determined a unique visitor. There are different techniques available, based on IP addresses or cookies or both.	8
View rate (Ratio of unique survey visitors/unique site visitors)	Requires counting unique visitors to the first page of the survey, divided by the number of unique site visitors (not page views!). It is not unusual to have view rates of less than 0.1 % if the survey is voluntary.	N/A

Participation rate (Ratio of unique visitors who agreed to participate/unique first survey page visitors)	Count the unique number of people who filled in the first survey page (or agreed to participate, for example by checking a checkbox), divided by visitors who visit the first page of the survey (or the informed consents page, if present). This can also be called "recruitment" rate.	9
Completion rate (Ratio of users who finished the survey/users who agreed to participate)	The number of people submitting the last questionnaire page, divided by the number of people who agreed to participate (or submitted the first survey page). This is only relevant if there is a separate "informed consent" page or if the survey goes over several pages. This is a measure for attrition. Note that "completion" can involve leaving questionnaire items blank. This is not a measure for how completely questionnaires were filled in. (If you need a measure for this, use the word "completeness rate".)	N/A – Because if programmes were cancelled they weren't able to progress to the end page.
Cookies used	Indicate whether cookies were used to assign a unique user identifier to each client computer. If so, mention the page on which the cookie was set and read, and how long the cookie was valid. Were duplicate entries avoided by preventing users access to the survey twice; or were duplicate database entries having the same user ID eliminated before analysis? In the latter case, which entries were kept for analysis (eg, the first entry or the most recent)?	N/A
IP check	Indicate whether the IP address of the client computer was used to identify potential duplicate entries from the same user. If so, mention the period of time for which no two entries from the same IP address were allowed (eg, 24 hours). Were duplicate entries avoided by preventing users with the same IP address access to the survey twice; or were duplicate database entries having the same IP address within a given period of time eliminated before analysis? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	8
Log file analysis	Indicate whether other techniques to analyze the log file for identification of multiple entries were used. If so, please describe.	N/A
Registration	In "closed" (non-open) surveys, users need to login first and it is easier to prevent duplicate entries from the same user. Describe how this was done. For example, was the survey never displayed a second time once the user had filled it in, or was the username stored together with the survey results and later eliminated? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	N/A

Handling of incomplete questionnaires	Were only completed questionnaires analyzed? Were questionnaires which terminated early (where, for example, users did not go through all questionnaire pages) also analyzed?	9,10 & Appendix 4
Questionnaires submitted with an atypical timestamp	Some investigators may measure the time people needed to fill in a questionnaire and exclude questionnaires that were submitted too soon. Specify the timeframe that was used as a cut-off point, and describe how this point was determined.	8
Statistical correction	Indicate whether any methods such as weighting of items or propensity scores have been used to adjust for the non-representative sample; if so, please describe the methods.	N/A

Appendix 2 - Electronic survey

Using technology to deliver the exercise component of cardiac rehabilitation

Start of Block: Default Question Block

Background Information Cardiac Rehabilitation is a vital treatment for patients recovering from a cardiac event. Exercise is a core component of a comprehensive cardiac rehabilitation programme, however, the outbreak of Covid-19 has meant that patients in many countries can no longer attend assessments and exercise classes in person. As a consequence, healthcare services have had to adopt new ways of working to ensure that their patients continue to receive cardiac rehabilitation services. Anecdotal evidence suggests that some cardiac rehabilitation services have begun using technology to deliver their assessments, physical activity advice, and/or exercise programmes remotely. The Covid-19 outbreak may therefore represent a step-change in services capacity to use the technology when the disease is brought under control. This may provide an opportunity to increase participation in cardiac rehabilitation among those who are unable or unwilling to travel to centre-based cardiac rehabilitation. This brief survey is designed to help the British Association for Cardiovascular Prevention and Rehabilitation understand if, or how, technology is being used to deliver the exercise component of cardiac rehabilitation. It will also capture professional experiences of using technology to deliver exercise-based cardiac rehabilitation and obtain an estimate of the patient demographic that are engaging with alternative delivery methods of cardiac rehabilitation.

Page Break

Thank you for taking the time to complete our brief survey. It should take approximately 10 minutes to complete.We have asked you to complete this survey because you are involved in the delivery of exercise-based cardiac rehabilitation and we want to understand how your practice has changed in relation to the COVID-19 outbreak. By proceeding to the next page of the survey you are providing consent to take part in the study. Only information that is essential to answer our research question will be collected. Any information collected will be helpful, and will be processed in accordance with the General Data Protection Regulation (2018). If you would like to withdraw from the study, just exit the web page. We will keep the responses you have provide even if you don't complete the whole survey. If you would like any information about data protection or the study, please contact: Dr Simon Nichols Advanced Wellbeing Research Centre Collegiate Hall Collegiate Crescent Sheffield Hallam University S10 2BP s.j.nichols@shu.ac.uk

○ Next page (1)

Page Break

Screening Q Have you previously completed this questionnaire?

- ○ Yes (1)
- ○ No (2)

Q1 Which phase of cardiac rehabilitation do you work in: (please tick the phase which you spend most of your time)

- ○ Phase I (1)
- ○ Phase II (2)
- ○ Phase III (3)
- ○ Phase IV (4)

Q2 Which country do you work in?

- ○ England (1)
- ○ Northern Ireland (2)
- ○ Scotland (3)
- ○ Wales (4)
- ○ Non-UK (please state) (5) _____

Page Break

Q3 Have you continued to provide exercise-based cardiac rehabilitation services during the COVID-19 outbreak?

- Yes – We are able to see as many patients as we did before the COVID-19 outbreak (1)
- Yes – But we aren't able to see as many patients as we did before the COVID-19 outbreak (2)
- No – All services have been cancelled/there are no staff to run our programmes (3)

Q4 Since the COVID-19 outbreak, has your service found that:

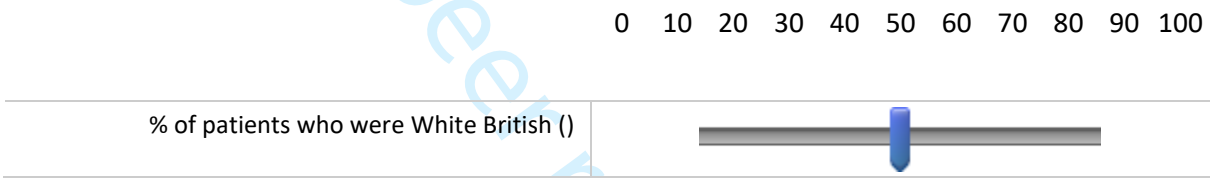
- The same number of patients are accessing exercise-based cardiac rehabilitation (1)
- Fewer patients are accessing exercise-based cardiac rehabilitation (2)
- No patients are accessing exercise-based cardiac rehabilitation (3)

Page Break

Q5 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to ethnicity?

- ☐ No - my patient population is less diverse (1)
- ☐ Yes - my patient population is as diverse as normal (2)
- ☐ No - my patient population is more diverse (3)

Q6 Only answer this question if you are a UK centre. Approximately what percentage of the patients you saw in the last 7 days were White British?



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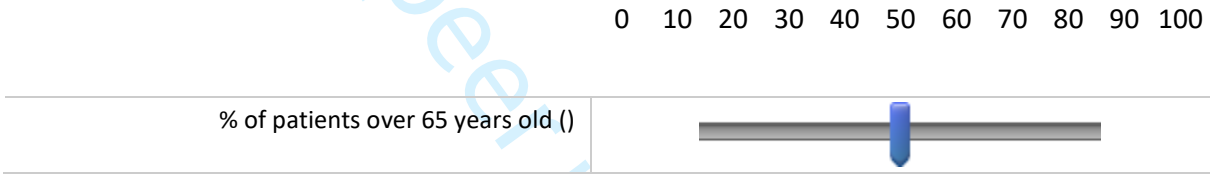
Q7 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to age?

- ○ No - my patient population is younger (1)
- ○ Yes - the age group of my patients is similar to normal (2)
- ○ No - my patient population is older (3)

Q8 Approximately what percentage of the patients you saw in the last 7 days were over 65 years old?



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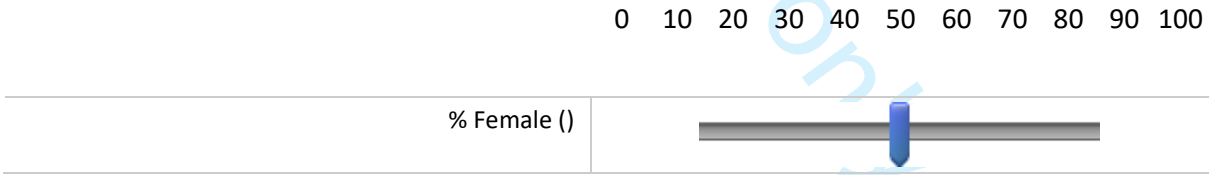
Q9 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to female participation?

- ○ No - the proportion of female participants is smaller (1)
- ○ Yes - the proportion of female participants is the same (2)
- ○ No -the proportion of female participants is larger (3)

Q10 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to male participation?

- ○ No - the proportion of male participants is smaller (1)
- ○ Yes - the proportion of male participants is the same (2)
- ○ No - the proportion of male participants is larger (3)

Q11 Approximately what percentage of the patients you saw in the last 7 days were female?



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Q12 Are you using any of the following technology to deliver a cardiac rehabilitation exercise assessment? (tick all that apply)

- ☐ Paper/postal services (1)
- ☐ Telephone (2)
- ☐ Text messaging (3)
- ☐ E-mail (4)
- ☐ Recorded video e.g. YouTube (5)
- ☐ Live video conferencing e.g. Zoom, Skype, Microsoft Teams, Facebook (6)
- ☐ Other (please state) (7) _____

Q13 How are you assessing functional capacity during your assessment? (tick all that apply)

- ☐ I am not assessing functional capacity (1)
- ☐ Self-reported fitness (2)
- ☐ Duke Activity Status Index/Other questionnaire (3)
- ☐ Step count from patients own physical activity tracker (4)
- ☐ Remotely supervised exercise test (please state which test) (5)
_____
- ☐ Other (please state) (6) _____

Q14 Are you using any of the following technology to deliver the physical activity/exercise component of cardiac rehabilitation? (tick all that apply)

- ☐ Paper/postal services (1)
- ☐ Telephone (2)
- ☐ Text messaging (3)
- ☐ E-mail (4)
- ☐ Recorded video e.g. YouTube (5)
- ☐ Live video conferencing e.g. Zoom, Skype, Microsoft Teams, Facebook (6)
- ☐ Other (please state) (7) _____

Page Break

Q15 Did you use this technology before the COVID-19 restrictions?

- ○ Yes (1)
- ○ No (2)

Q16 On approximately what date did you start using this technology?

_____

Q17 If you used remote technology before the COVID-19 restrictions, have you found that:

- ○ The same number of patients are accessing exercise-based cardiac rehabilitation using technology (1)
- ○ Fewer patients are accessing exercise-based cardiac rehabilitation using technology (2)
- ○ No patients are accessing exercise-based cardiac rehabilitation using technology (3)

Page Break

Q18 Are you able to use technology to deliver exercise-based cardiac rehabilitation to: (tick all that apply)

- [ ] Low risk patients (1)
- [ ] Moderate risk patients (2)
- [ ] High risk patients (3)

Q19 I am able to offer physical activity recommendations to patients that have not had an assessment in person? (i.e. in the same room as the assessor)

- ○ Yes (1)
- ○ No (2)

Q20 I am able to offer an exercise prescription to patients that have not had an assessment in person? (i.e. in the same room as the assessor)

- ○ Yes (1)
- ○ No (2)

*

Q21 Can you briefly describe what kind of physical activity recommendations you are making and/or exercises you are prescribing?

Examples may include chair-based exercise, resistance bands, walking, running on the spot and body weight exercises.

_____

_____

Page Break

Q22 How many supervised physical activity/exercise training sessions can a patient attend, each week?

_____

Q23 Are the physical activity/exercise sessions you are supervising: (tick all that apply)

- ☐ Group exercise (1)
- ☐ One-on-one (2)

*

Q24 How long is each supervised physical activity/exercise session? Please provide your answer in minutes.

_____

Page Break

*

Q25 How many unsupervised physical activity/exercise training sessions are you prescribing for a patient, each week?

_____

*

Q26 How long is each unsupervised physical activity/exercise session? Please provide your answer in minutes.

_____

Page Break

Q27 What intensity range do you recommend/prescribe? (tick all that apply)

- [ ] Low (e.g. RPE 11) (1)
- [ ] Moderate (e.g. RPE 13) (2)
- [ ] High (e.g. RPE 15) (3)

Q28 Is this intensity: (Tick one option only)

- ○ Lower than normal (1)
- ○ The same as normal (2)
- ○ Higher than normal (3)

Page Break

29 Do you think that the programmes you are providing are: (Tick one option only)

- ○ More effective than normal (1)
- ○ As effective as normal (2)
- ○ Less effective than normal (3)

Page Break

Q30 What barriers have you encountered when using technology to deliver cardiac rehabilitation? (tick all that apply)

- [ ] No barriers (1)
- [ ] Patients have no internet connection (2)
- [ ] Patients do not have access to computers/tablets/smart phone (3)
- [ ] Patients are not confident in using technology (4)
- [ ] Patients are concerned about personal safety (5)
- [ ] Patient lack of interest in receiving services using technology (6)
- [ ] My Trust/Health Board /employer do not support the delivery of health services using technology (7)
- [ ] Internet security and patient confidentiality concerns (8)
- [ ] Professionals are not confident in delivering services using technology (9)
- [ ] Professionals are concerned about patient safety (10)
- [ ] Other (please specify) (11) _____

Page Break

Q31 How many adverse events resulting in minor injury have been reported since you have started delivering cardiac rehabilitation remotely? Please only report incidents that are related to exercise-based cardiac rehabilitation.

_____

Page Break

Q32 How many adverse events resulting in life changing injury have been reported since you have started delivering cardiac rehabilitation remotely? Please only report incidents that are related to exercise-based cardiac rehabilitation.

_____

Page Break

Q33 How many adverse events resulting in death have been reported since you have started delivering cardiac rehabilitation remotely? Please only report incidents that are related to exercise-based cardiac rehabilitation.

_____

Page Break

Q34 Do you think that the way you are using technology now should be an option for patients in your future standard practice?

- ○ Yes (1)
- ○ No (2)

Page Break

*

Q35 Is there anything else you would like to tell us about your experience or approaches to delivering exercise-based cardiac rehabilitation using remote technology? (500 characters max)

_____

_____

_____

_____

_____

End of Block: Default Question Block

Appendix 3 - Recruitment material

Appendix 3a - E-mail to BACPR members on 2nd and 25th of June 2020

BACPR Survey - Use of remote technology to deliver the exercise component of cardiac rehabilitation.

Dear Member,

The outbreak of Covid-19 has meant that patients in many countries can no longer attend assessments and exercise classes in person. As a consequence, many healthcare services have had to adopt new ways of working to ensure that their patients continue to receive cardiac rehabilitation services. Anecdotal evidence suggests that some cardiac rehabilitation services have begun to use technology to deliver their assessments, physical activity advice, and/or exercise programmes, remotely. The Covid-19 outbreak may therefore represent a step-change in services capacity to use the technology when the disease is brought under control. This may provide an opportunity to increase participation in cardiac rehabilitation among those who are unable or unwilling to travel to centre-based cardiac rehabilitation, in the long-term.

To help improve the provision of cardiac rehabilitation in the future, we would be extremely grateful if you could take 10 minutes to complete a brief survey which will help the British Association for Cardiovascular Prevention and Rehabilitation understand if, or how, technology is being used to deliver the exercise component of cardiac rehabilitation. It will also capture your professional experiences of using technology to deliver exercise-based cardiac rehabilitation and obtain an estimate of the patient demographic that are engaging with alternative delivery methods of cardiac rehabilitation. The findings of the study will be disseminated through the BACPR as well as conferences, scientific publications, and if appropriate, training courses.

The survey can be completed on a desktop computer or a smart phone, and will take approximately 10 minutes. To proceed to the survey, click here.

Thank you for taking the time to consider taking part in this study.

Best wishes

Dr Simon Nichols

Simon Nichols

BACPR Scientific Chair

British Association for Cardiovascular Prevention & Rehabilitation

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Appendix 3b - Example Twitter advert posted on Twitter by the study authors on June 3rd 2020

RT #COVID19 is an unprecedented challenge to #cardiacrehab Please tell us if/how you are using technology to deliver the exercise component of CR by completing this 10 minute survey Down pointing backhand index https://shusls.eu.qualtrics.com/jfe/form/SV_eEgClDLGhsAE7Fr?Q_CHL=social&Q_SocialSource=twitter @bacpr @A_ODoherty @susandawkes @aynsleycowie @drtom_butler @SHU_PAWPH

Example advert posted by the BACPR Exercise Instructor Network on their Facebook page, on 8th June 2020

Appendix 3c - Calling all BACPR Members please check your email inboxes!!

We would greatly appreciate your help in completing our survey regarding the use of remote technology to deliver the exercise component of Cardiac Rehab. The findings of this study will be disseminated through the BACPR, conferences & scientific publications.

Question	Results reported in Manuscript	Phase I Responses	Phase II Responses	Phase III Responses	Phase IV Responses	Total Responses
Q1 Which phase of cardiac rehabilitation do you work in: (please tick the phase which you spend most of your time)	Yes – Page 7	14	29	164	123	330
Q2) Which country do you work in?	Yes – Page 7	14	29	164	123	330
Q3) Have you continued to provide exercise-based cardiac rehabilitation services during the COVID-19 outbreak?	Yes – Page 8 & Table 1	14	29	164	123	330
The following questions are applicable to a maximum of 167 respondents due to 163 programmes stating that their service had been suspended						
Q4 Since the COVID-19 outbreak, has your service found that: -The same number of patients are accessing exercise-based cardiac rehabilitation -Fewer patients are accessing exercise-based cardiac rehabilitation -No patients are accessing exercise-based cardiac rehabilitation	Yes – Page 8 & Table 1	8	17	102	34	161
Q5 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to ethnicity?	Yes – Page 8 & Table 1	7	16	95	33	151
Q6 Only answer this question if you are a UK centre. Approximately what percentage of the patients you saw in the last 7 days were White British?	Yes – Page 8 & Table 1	5	5	83	30	123
Q7 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to age?	Yes – Page 8 & Table 1	7	15	92	32	146
Q8 Approximately what percentage of the patients you saw in the last 7 days were over 65 years old?	Yes – Page 8 & Table 1	7	13	88	31	139
Q9 Are the patients you are currently treating representative of the	Yes – Page 8 & Table 1	6	15	85	29	135

patients you would treat under normal circumstances, with respect to female participation?						
Q10 Are the patients you are currently treating representative of the patients you would treat under normal circumstances, with respect to male participation?	Yes – Table 1	6	15	85	29	135
Q11 Approximately what percentage of the patients you saw in the last 7 days were female?	Yes – Page 8 & Table 1	6	14	77	28	125
Q12 Are you using any of the following technology to deliver a cardiac rehabilitation exercise assessment?	Yes – Page 9 & Figure 2	6	14	84	29	133
Q13 How are you assessing functional capacity during your assessment?	Yes – Page 9	6	14	84	29	133
Q14 Are you using any of the following technology to deliver the physical activity/exercise component of cardiac rehabilitation?	Yes – Page 11 & Figure 3	6	14	84	29	133
Q15 Did you use this technology before the COVID-19 restrictions?	Yes - Page 8	6	14	81	27	128
Date of technology adoption	Yes – Page 8	5	14	80	27	126
Q17 If you used remote technology before the COVID-19 restrictions, have you found that: -The same number of patients are accessing exercise-based cardiac rehabilitation using technology -Fewer patients are accessing exercise-based cardiac rehabilitation using technology -No patients are accessing exercise-based cardiac rehabilitation using technology	No	6	7	44	8	65

Q18 Are you able to use technology to deliver exercise-based cardiac rehabilitation to: -Low risk patients -Moderate risk patients -High risk patients	Yes – Page 11	6	12	79	26	123
Q19 I am able to offer physical activity recommendations to patients that have not had an assessment in person? (i.e. in the same room as the assessor)	Yes – Page 11	6	12	79	26	123
Q20 I am able to offer an exercise prescription to patients that have not had an assessment in person? (i.e. in the same room as the assessor)	Yes – Page 11	6	12	79	26	123
Q21 Can you briefly describe what kind of physical activity recommendations you are making and/or exercises you are prescribing?	No	6	7	44	8	65
Q22 How many supervised physical activity/exercise training sessions can a patient attend, each week?	No	6	11	72	26	115
Q23 Are the physical activity/exercise sessions you are supervising: Group exercise One-on-one	No	5	8	24	24	61
Q24 How long is each supervised physical activity/exercise session? Please provide your answer in minutes.	No	5	8	25	26	64
Q25 How many unsupervised physical activity/exercise training sessions are you prescribing for a patient, each week?	No	5	10	70	24	109

Q26 How long is each unsupervised physical activity/exercise session? Please provide your answer in minutes.	No	4	9	56	12	81
Q27 What intensity range do you recommend/prescribe?	No	6	9	70	24	109
Q28 Is this intensity	No	6	9	70	24	109
Q29 Do you think that the programmes you are providing are:	No	6	9	70	24	109
Q30 What barriers have you encountered when using technology to deliver cardiac rehabilitation? (tick all that apply)	Yes – Page 11 & Table 2	6	9	68	24	107
Q31 How many adverse events resulting in minor injury have been reported since you have started delivering cardiac rehabilitation remotely?	Yes – Page 11	6	9	68	24	107
Q32 How many adverse events resulting in life changing injury have been reported since you have started delivering cardiac rehabilitation remotely?	Yes – Page 11	6	9	68	24	107
Q33 How many adverse events resulting in death have been reported since you have started delivering cardiac rehabilitation remotely?	Yes – Page 11	6	9	68	24	107
Q34 Do you think that the way you are using technology now should be an option for patients in your future standard practice?	Yes – Page 15	6	8	68	24	106
Q35 Is there anything else you would like to tell us about your experience or approaches to delivering exercise-based cardiac rehabilitation using remote technology?	Yes – Qualitative synthesis; Pages 12-15	1	4	39	13	57