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Development of a Home-Based Pulmonary Rehabilitation Program for Long COVID in Jordan: A Modified e-Delphi Study

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Abstract

Long COVID is associated with persistent symptoms such as fatigue, dyspnea, and reduced functional capacity that impair quality of life. Although pulmonary rehabilitation is recommended, access to center-based programmes remains limited, particularly in low- and middle-income settings. Home-based pulmonary rehabilitation (HBPR) may offer a feasible alternative; however, standardized programmes for Long COVID are lacking. The aim of this study was to develop a consensus-based, evidence-informed HBPR programme for individuals with Long COVID using a modified e-Delphi approach.

A modified e-Delphi study was conducted involving 15 multidisciplinary experts in pulmonary rehabilitation and Long COVID management. In Round 1, qualitative data from open-ended questions were analyzed thematically to generate preliminary programme components. In Round 2, experts rated the importance and feasibility of each item using a 5-point Likert scale. Consensus was defined as ≥ 70% agreement and a median score of ≥ 4.

A total of 97 statements were evaluated in Round 2. Consensus was achieved for 90 statements (92.8%), while 7 statements were excluded due to lack of consensus. Strong agreement was observed for programme structure, safety, and exercise prescription. The final HBPR programme incorporated pacing strategies, symptom-contingent progression, and screening for post-exertional malaise. Lower feasibility ratings were observed for components requiring intensive supervision or advanced technology.

This study developed a consensus-based, evidence-informed HBPR programme for individuals with Long COVID. The findings provide a structured and adaptable framework to support rehabilitation delivery in resource-limited settings. Future studies should evaluate the programme's feasibility and clinical effectiveness.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has resulted in a substantial global burden extending beyond the acute phase of infection. Many individuals continue to experience persistent symptoms weeks to months after the initial illness, a condition referred to as Long COVID or post-COVID-19 condition Common manifestations include fatigue, dyspnea, cognitive dysfunction, and reduced functional capacity, which negatively affect quality of life and daily functioning [1] Fatigue and dyspnea are among the most prevalent and disabling symptoms, often contributing to prolonged functional limitations [2, 3]Large cohort and patient-led studies further highlight the heterogeneous and multisystem nature of Long COVID [4, 5].

In Jordan, Long COVID has emerged as a clinically significant condition. A recent cross-sectional study reported that approximately 27% of individual's experience persistent symptoms beyond one month after COVID-19 infection, indicating a considerable burden of ongoing post-COVID sequelae within the population [6]. These symptoms adversely affect physical functioning and quality of life, while access to structured rehabilitation services remains limited, highlighting an important gap in post-COVID care.

Pulmonary rehabilitation (PR) is an established intervention for chronic respiratory diseases and has been increasingly adapted for individuals recovering from COVID-19 [7]. Multicomponent programmes incorporating aerobic exercise, resistance training, and breathing exercises have demonstrated benefits in exercise capacity, symptom burden, and quality of life [8]. However, access to conventional center-based PR remains limited in low- and middle-income countries (LMICs) because of challenges related to infrastructure, workforce capacity, and accessibility [9]. Evidence from Malaysia demonstrated that home-based pulmonary rehabilitation can be delivered safely and effectively using minimal resources, although barriers related to monitoring capacity, caregiver support, and healthcare infrastructure remain [10]. These findings emphasize the need for feasible and context-specific rehabilitation models for resource-limited settings.

Home-based pulmonary rehabilitation (HBPR) has therefore emerged as a promising alternative, often supported by remote or low-technology approaches such as phone-based follow-up [11–13]. Nevertheless, existing rehabilitation approaches may not adequately address the fluctuating symptom profile of Long COVID, particularly post-exertional malaise (PEM). Current guidance recommends individualized, symptom-contingent rehabilitation rather than fixed exercise progression[14]. In resource-limited settings such as Jordan, additional challenges related to service availability and implementation further reinforce the need for adaptable rehabilitation strategies.

Despite increasing recognition of pulmonary rehabilitation in post-COVID management, there remains a lack of standardized and context-specific HBPR programmes tailored to individuals with Long COVID in low-resource settings. Therefore, this study aimed to develop a consensus-based, Long COVID-specific home-based pulmonary rehabilitation (HBPR) programme tailored to the Jordanian context using a modified e-Delphi approach.

RESULTS

Expert Panel Characteristics

A total of 15 experts participated in both rounds of the Delphi study, representing a multidisciplinary panel with clinical and academic expertise in pulmonary rehabilitation and Long COVID management. The response rate for Round 2 was 100%.

The majority of participants were physiotherapists (n = 12, 80%), while the remaining experts were rehabilitation physicians (n = 3, 20%). All experts had relevant experience in pulmonary rehabilitation and Long COVID management, with a minimum of five years of professional experience as per the inclusion criteria.

Participants were drawn from diverse professional settings, including rehabilitation centers, hospitals, academic institutions, and mixed clinical–academic roles. All experts were based in Jordan. The characteristics of the expert panel are summarized in Table 1.

Table 1
Characteristics of the expert panel (N = 15)

Variable	n (%)
Number of experts	15 (100%)
Profession	
Physiotherapists	12 (80%)
Rehabilitation physicians	3 (20%)
Academic qualification	
Bachelor's degree	2 (13.3%)
Master's degree	5 (33.3%)
PhD	8 (53.3%)
Professional role	
Clinical	8 (53.3%)
Clinical + academic	5 (33.3%)
Academic	2 (13.3%)
Area of expertise	
Pulmonary rehabilitation	15 (100%)
Long COVID management	15 (100%)
Work setting	
Rehabilitation centers	4 (26.7%)
Hospital + rehabilitation	3 (20%)
Academic + rehabilitation	2 (13.3%)
Academic institutions	1 (6.7%)
Public hospital + academic	1 (6.7%)
Academic + research	1 (6.7%)
Public hospital + rehabilitation	1 (6.7%)
Public hospital + research	1 (6.7%)
Private hospital + academic	1 (6.7%)

Key Features and Long COVID-Specific Adaptations of the HBPR Programme

Importantly, the consensus did not merely replicate traditional pulmonary rehabilitation models. While core components such as aerobic exercise, resistance training, and breathing exercises were retained, several Long COVID-specific adaptations were identified. These included the integration of pacing strategies, screening for post-exertional malaise (PEM), and the use of symptom-contingent and flexible exercise progression rather than fixed intensity protocols. In addition, the programme emphasized low-technology delivery models, simplified monitoring approaches, and caregiver involvement to enhance feasibility and accessibility in resource-limited settings.

Round 1: Qualitative Findings

In Round 1, qualitative responses were analyzed using an inductive thematic analysis approach to explore expert perspectives on the essential components of a home-based pulmonary rehabilitation (HBPR) programme for individuals with Long COVID. Responses were reviewed systematically and organized into categories based on recurring ideas across expert inputs. These categories were subsequently grouped into broader domains representing key components of pulmonary rehabilitation programmes, with similar responses merged and redundant items removed to ensure clarity and coherence. A total of six key domains were identified, including programme structure and delivery, eligibility and safety screening, monitoring and red-flag criteria, exercise prescription, education and self-management, patient-centered adaptation, and outcome measures.

Experts emphasized the importance of a structured yet flexible programme design, incorporating remote supervision and adaptable delivery models to enhance accessibility and adherence. Safety considerations were highlighted as critical, including baseline assessment, ongoing monitoring, and clear red-flag criteria. A multicomponent rehabilitation approach was strongly supported, integrating breathing exercises, aerobic training, resistance training, and functional activities, with individualized progression and symptom-guided intensity, particularly in the context of fluctuating symptoms and post-exertional malaise.

Education and self-management strategies, including pacing, energy conservation, and symptom monitoring, were consistently identified as essential. Experts also highlighted the importance of tailoring the programme to individual needs, cultural context, and resource availability. These findings were synthesized and translated into 97 structured, non-redundant statements for evaluation in Round 2 Key outcome measures included fatigue, quality of life, functional capacity, dyspnea, and psychological status, and the main qualitative domains and themes are summarized in Table 2.

Table 2
Summary of qualitative findings from Round 1

Domain	Key themes	Description
Programme structure and delivery	Structured programme; remote supervision	Experts emphasized the need for a structured program supported by remote supervision to enhance adherence.
Eligibility and safety screening	Patient selection; safety screening	Appropriate patient selection and safety screening were considered essential for safe implementation.
Monitoring and red-flag criteria	Monitoring: symptom tracking, red flags	Continuous monitoring and early identification of warning signs were highlighted to ensure safety.
Exercise prescription	Gradual progression; pacing; individualization	Exercise should be individualized, with gradual progression and pacing strategies.
Education and self-management	Education; self-monitoring	Patient education and self-monitoring were considered key for safe participation.
Patient-centered adaptations	Individualization; flexibility	Programme adaptation based on patient needs and symptom variability was emphasized.
Outcome measures	Functional outcomes; symptoms; QoL	Monitoring functional outcomes, symptoms, and quality of life was recommended.

Round 2: Consensus Findings

Overall, consensus was achieved for 90 out of 97 statements (92.8%), which were retained in the final HBPR programme, while 7 statements (7.2%) did not meet the predefined consensus criteria and were excluded. Notably, all excluded items were associated with lower feasibility ratings rather than a lack of perceived importance. These items were primarily related to supervision intensity, the use of advanced technology for programme delivery, and higher-intensity or resource-dependent components, including enhanced monitoring and structured progression strategies. This pattern indicates variability in perceived feasibility, particularly for elements requiring greater resources, specialized supervision, or technological infrastructure within the local healthcare context.

Overall, agreement levels were consistently high across domains for importance ratings, whereas feasibility ratings were comparatively lower for selected components. The level of agreement across domains is presented in Fig. 3, and detailed domain-level findings are summarized in Table 3). Detailed item-level consensus results from Round 2 are presented in Table 4, showing the percentage agreement, median scores, and final decision for each item, and seven items did not reach consensus and were excluded, primarily due to feasibility concerns within the Jordanian healthcare context (Table 5).

Table 3
Summary of expert consensus on HBPR programme components across domains (Round 2 Delphi results)

Domain	Importance Median (IQR)	Feasibility Median (IQR)	Importance Agreement % (Range)	Feasibility Agreement % (Range)
Programme Structure	4 (4–5)	4 (4–5)	93.33 (80–100)	90 (75–100)
Supervision & Delivery	5 (4–5)	4 (3–5)	98.67 (93.33–100)	77.33 (40–100)
Eligibility & Safety	5 (4–5)	4 (4–4)	97.33 (93.33–100)	81.33 (33.33–100)
Safety Monitoring	5 (4–5)	4 (4–5)	100 (100–100)	83.33 (53.33–100)
Red Flags	5 (5–5)	5 (4–5)	98.67 (93.33–100)	100 (100–100)
Breathing Exercises	5 (4–5)	5 (4–5)	97.78 (93.33–100)	100 (100–100)
Aerobic Exercise	5 (4–5)	5 (4–5)	97.78 (93.33–100)	82.22 (53.33–100)
Resistance Training	5 (4–5)	4 (4–5)	97.78 (93.33–100)	88.89 (80–93.33)
Flexibility & Functional	5 (4–5)	5 (4–5)	91.11 (73.33–100)	80 (40–100)
Education & Self-Management	4 (4–5)	4 (4–5)	100 (100–100)	95.55 (93.33–100)
Patient-Centered Adaptation	5 (4–5)	4 (4–5)	100 (100–100)	80 (33.33–100)
Outcome Measures	4 (4–5)	5 (4–5)	100 (100–100)	100 (100–100)

Table 4
Item-level consensus results of Round 2 e-Delphi for the home-based pulmonary rehabilitation (HBPR) programme

Item	N	Agreement (4–5)	Consensus (%)	Median	Decision
An 8-week intensive HBPR programme is appropriate	15	15	100	4	Retained
A 12-week programme duration is more appropriate than 8 weeks	15	12	80	4	Retained
A structured maintenance phase beyond the intensive phase is necessary	15	15	100	5	Retained
Bi-weekly supervised contact is appropriate during the intensive phase (importance)	15	15	100	4	Retained
Weekly supervision is necessary during early phases or severe cases (importance)	15	15	100	5	Retained
Phone-based supervision is the primary mode of delivery (importance)	15	14	93.33	4	Retained
A hybrid model (phone + video support) is preferable (importance)	15	15	100	5	Retained
App-based delivery is optional rather than mandatory (importance)	15	15	100	5	Retained
Bi-weekly supervised contact is appropriate during the intensive phase (feasibility)	15	15	100	4	Retained
Weekly supervision is necessary during early phases or severe cases (feasibility)	15	6	40	3	Excluded
Phone-based supervision is the primary mode of delivery (feasibility)	15	15	100	5	Retained
A hybrid model (phone + video support) is preferable (feasibility)	15	6	40	3	Excluded
App-based delivery is optional rather than mandatory (feasibility)	15	15	100	5	Retained

Consensus was defined as ≥ 70% agreement (ratings of 4 or 5) and a median score ≥ 4. N = number of experts; Consensus (%) = percentage of experts rating the item as 4 or 5. Retained indicates statements that reached consensus and were included in the final programme, whereas Excluded indicates statements that did not reach consensus.

Item	N	Agreement (4–5)	Consensus (%)	Median	Decision
Only clinically stable patients are eligible for HBPR (importance)	15	15	100	5	Retained
Baseline cardiac screening is mandatory before enrolment (importance)	15	14	93.33	4	Retained
Baseline respiratory assessment is required before enrolment (importance)	15	15	100	5	Retained
Screening for post-exertional malaise (PEM) should be conducted before exercise prescription (importance)	15	14	93.33	5	Retained
Patients with comorbidities require individualized low-intensity prescriptions and closer monitoring (importance)	15	15	100	5	Retained
Only clinically stable patients are eligible for HBPR (feasibility)	15	14	93.33	5	Retained
Baseline cardiac screening is mandatory before enrolment (feasibility)	15	5	33.33	3	Excluded
Baseline respiratory assessment is required before enrolment (feasibility)	15	15	100	4	Retained
Screening for post-exertional malaise (PEM) should be conducted before exercise prescription (feasibility)	15	12	80	4	Retained
Patients with comorbidities require individualized low-intensity prescriptions and closer monitoring (feasibility)	15	15	100	4	Retained
Heart rate monitoring is mandatory during HBPR (importance)	15	15	100	4	Retained
The Borg Rating of Perceived Exertion (RPE) scale should guide exercise intensity (importance)	15	14	93.33	5	Retained

Consensus was defined as ≥ 70% agreement (ratings of 4 or 5) and a median score ≥ 4. N = number of experts; Consensus (%) = percentage of experts rating the item as 4 or 5. Retained indicates statements that reached consensus and were included in the final programme, whereas Excluded indicates statements that did not reach consensus.

Item	N	Agreement (4–5)	Consensus (%)	Median	Decision
A structured symptom diary/logbook is required (importance)	15	15	100	4	Retained
SpO_2 monitoring is included as a core safety parameter (importance)	15	15	100	5	Retained
Heart rate monitoring is mandatory during HBPR (feasibility)	15	12	80	4	Retained
The Borg Rating of Perceived Exertion (RPE) scale should guide exercise intensity (feasibility)	15	14	93.33	5	Retained
A structured symptom diary/logbook is required (feasibility)	15	15	100	4	Retained
SpO_2 monitoring is included as a core safety parameter (feasibility)	15	9	60	4	Excluded
Chest pain during HBPR should prompt immediate cessation and medical referral (importance)	15	15	100	5	Retained
A drop in SpO_2 below a predefined threshold should trigger escalation (importance)	15	15	100	5	Retained
Abnormal HR/BP responses require reassessment (importance)	15	15	100	5	Retained
Worsening PEM symptoms should lead to programme modification (importance)	15	14	93.33	5	Retained
Syncope or neurological symptoms require urgent referral (importance)	15	15	100	5	Retained

Consensus was defined as ≥ 70% agreement (ratings of 4 or 5) and a median score ≥ 4. N = number of experts; Consensus (%) = percentage of experts rating the item as 4 or 5. Retained indicates statements that reached consensus and were included in the final programme, whereas Excluded indicates statements that did not reach consensus.

Table 5
Items not reaching consensus in Round 2 e-Delphi and corresponding decisions

Domain	Decision	Median	Justification
Supervision (Feasibility)	Exclude.	3	Limited feasibility in the local context
Supervision (Feasibility)	Exclude.	3	Implementation challenges
Eligibility (Feasibility)	Exclude.	3	Practical constraints in application
Safety Monitoring (Feasibility)	Exclude.	4	Resource limitations
Aerobic Exercise (Feasibility)	Exclude.	4	Limited applicability for some patients
Functional Training (Feasibility)	Exclude.	4	Variability in home environments
Patient-Centered Adaptation (Feasibility)	Exclude.	3	Limited support systems
Consensus was defined as ≥ 70% agreement (ratings of 4 or 5) with a median score ≥ 4.			
Exclu. = excluded item.			

Domain-Specific Consensus Findings

High levels of consensus were observed across all domains, reflecting a coherent and structured approach to programme development. Experts supported a phased rehabilitation pathway comprising an initial intensive phase (8–12 weeks), followed by a maintenance phase to promote long-term adherence. Remote delivery models, particularly phone-based and hybrid approaches, were strongly endorsed, with supervision frequency tailored to patient condition.

Eligibility criteria emphasized the inclusion of clinically stable individuals, with the need for baseline cardiac and respiratory assessment before programme initiation, and additional monitoring for those with comorbidities. Safety monitoring was consistently identified as a core component, alongside the recognition of key red-flag symptoms requiring clinical attention.

A multicomponent rehabilitation approach was recommended, integrating breathing exercises, aerobic and resistance training, and functional activities, with intensity guided by perceived exertion and adapted for individuals at risk of post-exertional symptom exacerbation. Experts also highlighted the importance of education and self-management strategies, including pacing and energy conservation, as well as the need for flexible, culturally appropriate, and low-technology delivery models in resource-limited settings.

Consensus was also achieved regarding outcome measures, with fatigue and quality of life identified as primary outcomes, alongside functional capacity, dyspnea, and psychological status as key secondary outcomes.

Development of the HBPR Programme

Based on the consensus findings from Round 2, qualitative inputs from Round 1, and supporting evidence from the prior systematic review, a structured home-based pulmonary rehabilitation (HBPR) programme was developed. The programme follows a phased structure consisting of an initial intensive phase (8–12 weeks), followed by a maintenance phase to support sustained engagement. It is designed for home-based delivery, with sessions conducted three times per week and supported by low-technology remote supervision.

The intervention is initiated through a face-to-face or virtual session to provide instruction on exercise performance, pacing strategies, and symptom monitoring, followed by regular phone-based follow-up to reinforce adherence and adjust the programme based on patient response. Each session incorporates a multicomponent design, including breathing exercises, aerobic training, resistance exercises, and functional activities. Exercise prescription is guided by perceived exertion and symptom tolerance rather than fixed intensity targets, with progression individualized and symptom-contingent, particularly in the presence of post-exertional malaise (PEM).

Safety and monitoring are embedded within the programme structure through the use of low-technology strategies, including the Borg Rating of Perceived Exertion (RPE) scale and structured symptom diaries, supported by clear red-flag criteria for exercise modification or clinical referral. In addition, education, pacing strategies, and caregiver involvement are integrated as core components to enhance adherence, self-management, and long-term sustainability. The detailed structure and components of the HBPR programme are presented in Table 6.

Table 6
Proposed Home-Based Pulmonary Rehabilitation Programme for Long COVID

Component	Description
Programme duration	Initial intensive phase of 8–12 weeks, followed by a maintenance phase to support long-term adherence
Frequency	Three sessions per week
Session duration	Approximately 30–60 minutes per session, depending on patient tolerance
Delivery mode	Home-based, self-administered programme supported by remote supervision. Initial instruction is provided via face-to-face or virtual session to ensure correct performance of exercises and understanding of pacing strategies, followed by ongoing phone-based follow-up (low-technology tele rehabilitation approach)
Supervision	Weekly or bi-weekly follow-up via phone calls to monitor symptoms, reinforce adherence, and adjust exercise prescription based on patient response, including identification of post-exertional malaise (PEM) and modification of activity accordingly
Breathing exercises	Diaphragmatic breathing and inspiratory muscle training (IMT), initiated at low intensity with gradual progression based on tolerance
Aerobic training	Walking as the primary modality, with intensity guided by Borg Rating of Perceived Exertion (RPE). Interval-based training may be used for patients with dyspnea or post-exertional malaise
Resistance training	Sit-to-stand exercises and resistance bands (e.g., TheraBand), performed at low-to-moderate intensity with individualized progression
Flexibility and functional training	Stretching exercises and activities of daily living (ADL)-based functional training
Progression strategy	Symptom-contingent and individualized progression based on perceived exertion, symptom response, and tolerance. Exercise intensity may be reduced or temporarily paused in case of symptom exacerbation or post-exertional malaise (PEM)
Monitoring	Low-technology monitoring including Borg RPE scale, structured symptom diary/logbook, and patient-reported symptoms. Heart rate monitoring may be used where available, but is not mandatory, with symptom-based monitoring considered the primary approach
Red-flag criteria	Chest pain, severe breathlessness, dizziness, syncope, or worsening symptoms requiring exercise modification or clinical referral
Education and self-management	Pacing and energy conservation strategies, breathing techniques, symptom monitoring, and goal-setting
Caregiver involvement	Encouraged to support adherence, safety, and patient engagement
Patient-centered adaptation	Low-technology delivery (phone-based), culturally tailored content, and adaptability for resource-limited settings

Component	Description
Outcome measures	Fatigue, quality of life, functional capacity (1-minute sit-to-stand test), dyspnea (mMRC), and psychological status (e.g., HADS)

DISCUSSION

This study developed a context-specific home-based pulmonary rehabilitation (HBPR) programme for individuals with Long COVID, emphasizing flexible and symptom-guided rehabilitation strategies suitable for resource-limited settings. These findings align with international recommendations supporting pulmonary rehabilitation for post-COVID conditions[3, 7]. While multicomponent rehabilitation programmes have demonstrated benefits in functional capacity, symptom burden, and quality of life, the present study extends current evidence by incorporating Long COVID-specific adaptations, including pacing strategies, symptom-contingent progression, and screening for post-exertional malaise (PEM). In addition, the use of low-technology delivery approaches enhances programme feasibility in real-world settings .[15]

Breathing exercises, particularly diaphragmatic breathing and inspiratory muscle training (IMT), achieved strong expert consensus, reflecting their role in improving respiratory function and reducing dyspnea in post-COVID populations[16]. Aerobic training, mainly walking, was identified as the primary exercise modality, with intensity guided by perceived exertion rather than fixed workload targets, consistent with current recommendations for individualized rehabilitation in Long COVID [15].

A key distinction from conventional pulmonary rehabilitation is the management of PEM. Unlike traditional rehabilitation models that use structured exercise progression [7], Long COVID rehabilitation requires more adaptive strategies due to symptom exacerbation following exertion. Accordingly, pacing and symptom-contingent progression provide a safer framework for regulating activity while minimizing symptom worsening [14].

Resistance and functional training, particularly sit-to-stand and resistance band exercises, were also identified as important programme components for addressing muscle deconditioning and improving functional independence [17]. The use of simple, low-cost exercises further supports programme scalability in resource-constrained settings.

Strong consensus was also achieved regarding remote supervision through phone-based and hybrid delivery models. These findings support the growing role of tele-rehabilitation in improving access to rehabilitation services while reducing dependence on advanced technologies [11, 13]. However, lower feasibility ratings for some technology-dependent components highlight challenges related to digital literacy, infrastructure, and resource availability in low-resource settings.

Safety monitoring was considered a central component of the programme, with emphasis on symptom tracking and perceived exertion. Although objective measures such as heart rate and oxygen saturation

may be used when available, the programme primarily relies on practical low-technology strategies, including the Borg Rating of Perceived Exertion (RPE) scale, symptom diaries, and clear red-flag criteria. This reflects a pragmatic balance between safety and feasibility and aligns with recommendations for individualized rehabilitation in Long COVID [9].

Education and self-management strategies, particularly pacing and energy conservation, were also consistently emphasized due to the central role of fatigue and post-exertional symptom exacerbation in Long COVID [14].

An important finding of this study was the discrepancy between importance and feasibility ratings across several programme components. While most interventions were considered highly important, lower feasibility ratings were observed for components requiring intensive supervision, advanced monitoring, or technology-based delivery. Notably, items failing to reach consensus were excluded because of feasibility limitations rather than lack of perceived value. These findings highlight the challenges of implementing complex rehabilitation interventions in resource-limited settings and emphasize the importance of context-specific adaptation when translating evidence into practice[18] .

Importantly, this study extends existing pulmonary rehabilitation frameworks by providing a feasibility-informed and context-specific model tailored to individuals with Long COVID in low-resource settings. By integrating evidence from a systematic review with expert consensus, the proposed HBPR programme offers a structured and adaptable rehabilitation framework with potential applicability across similar healthcare contexts[19] .

This study has several strengths, including the integration of systematic review evidence with expert consensus to develop a clinically relevant rehabilitation programme. The modified e-Delphi approach enabled iterative refinement and incorporation of multidisciplinary perspectives, while the explicit consideration of feasibility enhances the potential for real-world implementation.

LIMITATIONS

This study has several limitations. The relatively small purposive sample and reliance on expert opinion may limit the generalizability of the findings. Although the panel was multidisciplinary, physiotherapists represented the majority, and inclusion of additional healthcare professionals may have provided broader perspectives. The study was conducted within the Jordanian context, which may affect transferability to other settings. In addition, patient perspectives were not included, and the programme has not yet been evaluated in practice. Future research should incorporate more diverse multidisciplinary panels, include patient involvement, and assess the programme through feasibility and controlled studies.

CONCLUSION

This study developed a consensus-based, evidence-informed home-based pulmonary rehabilitation (HBPR) programme for individuals with Long COVID using a modified e-Delphi approach. Strong expert

agreement was achieved on a structured, multicomponent programme integrating exercise, safety monitoring, education, and patient-centered adaptations suitable for resource-limited settings. The proposed programme provides a practical rehabilitation framework, and future studies should evaluate its feasibility, acceptability, and clinical effectiveness.

METHODS

Study Design

This study employed a modified e-Delphi design to develop a consensus-based home-based pulmonary rehabilitation (HBPR) programme for individuals with Long COVID, integrating expert opinion with prior evidence synthesis. The study represents the development phase of a broader research programme guided by the Medical Research Council (MRC) framework for complex interventions [20]. Patient and public involvement was not included at this stage but is planned for subsequent phases of programme refinement and evaluation.

Participants and Recruitment

Experts were purposively recruited based on their clinical and/or academic expertise in pulmonary rehabilitation and Long COVID management. Eligibility criteria included: (1) active involvement in pulmonary rehabilitation or a related specialty; (2) a minimum of five years of relevant clinical or research experience; and (3) willingness to participate in all Delphi rounds.

The expert panel was multidisciplinary, comprising physiotherapists, rehabilitation physicians, and academic researchers. Physiotherapists represented the majority of the panel, reflecting their central role in the design and delivery of pulmonary rehabilitation programmes. Rehabilitation physicians contributed clinical oversight and medical perspectives, while academic experts provided research-informed insights to support evidence-based programme development. This composition was intended to ensure a comprehensive perspective integrating clinical practice and research expertise.

Development of the Delphi Questionnaire

The Delphi questionnaire was developed based on findings from a prior systematic review and relevant literature. Initial domains were informed by existing evidence and further refined based on expert input to reflect key components of pulmonary rehabilitation for individuals with Long COVID.

The questionnaire was structured into the following domains: programme structure and delivery; eligibility and safety screening; monitoring and red-flag criteria; exercise prescription (including breathing, aerobic, resistance, and functional training); education and self-management; patient-centered adaptations; and outcome measures.

Delphi Procedure

A two-round modified e-Delphi process was employed in this study and conducted using an online survey platform (Google Forms). Each round was completed asynchronously, allowing participants to respond at their convenience within a predefined time frame of 5–7 days. Reminder emails were sent to enhance response rates and ensure completion of both rounds. The Delphi process was conducted anonymously to minimize the influence of dominant individuals and to enable independent judgment. The overall study process is illustrated in Fig. 1.

All invited experts participated in both rounds, ensuring consistency of responses across the Delphi process with no attrition observed. Before Round 2, the questionnaire was pilot-tested for clarity and comprehensibility, and no modifications were required based on pilot feedback. In this modified approach, individual feedback from Round 1 was not provided to participants in Round 2 in order to minimize potential conformity bias and allow independent evaluation of each statement. Qualitative data obtained in Round 1 were analyzed using a structured thematic approach, and the resulting themes were systematically translated into 97 statements for quantitative rating in Round 2. A two-round design was considered sufficient, as a high level of consensus was achieved in Round 2, with the majority of statements meeting the predefined consensus criteria. Given this level of agreement and the observed response stability, an additional round was deemed unlikely to result in substantial changes. No additional qualitative comments were provided during Round 2, and therefore, no further modifications to the statements were required following the quantitative assessment.

Round 1: Qualitative Exploration

Round 1 qualitative data were analyzed using an inductive thematic analysis approach following the framework proposed by Virginia Braun and Victoria Clarke [21]. All responses were read repeatedly to achieve familiarization and to develop a comprehensive understanding of expert perspectives.

Initial codes were generated inductively without the use of a predefined coding framework, allowing themes to emerge directly from the data. These codes captured key concepts related to programme structure, delivery, safety, monitoring, and patient management. Codes were then grouped into broader categories based on conceptual similarity and further refined into overarching domains representing the key components of the home-based pulmonary rehabilitation (HBPR) programme.

The domains were iteratively reviewed and refined to ensure internal coherence and clear distinctions between categories. To enhance credibility, a second researcher independently reviewed a subset of the data and coding structure. Any discrepancies were discussed and resolved through consensus. An audit trail documenting coding decisions and theme development was maintained throughout the analysis to ensure transparency and dependability, while confirmability was achieved by grounding all interpretations in participants' responses.

The transformation from raw qualitative data into structured Delphi statements followed a systematic process involving coding, categorization, and domain development. Duplicate and overlapping concepts were removed, and the remaining items were refined into clear, concise, and clinically relevant statements. A total of 97 statements were generated and organized into predefined domains for evaluation in Round 2.

Round 2: Consensus Process

In Round 2, the statements derived from Round 1 were presented in a structured questionnaire comprising 97 items grouped into predefined domains. These domains reflected the key components of the HBPR programme identified during the qualitative analysis.

Experts were asked to rate each statement in terms of its importance and feasibility within the Jordanian healthcare context using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). In addition, a free-text comment section was provided to allow participants to suggest modifications, clarify responses, or provide further insights.

The statements included in Round 2 were developed through an iterative refinement process that involved grouping similar responses, removing duplicate or overlapping items, and rephrasing statements to enhance clarity, relevance, and consistency across domains.

Data Analysis

For Round 1, qualitative data were analyzed using an inductive thematic analysis approach to identify key themes and domains relevant to the development of the HBPR programme.

For Round 2, data were analyzed using descriptive statistics. For each item, the percentage of agreement defined as the proportion of experts rating the item as 4 or 5 was calculated, along with the median and interquartile range (IQR) to summarize central tendency and variability.

Consensus was predefined as at least 70% agreement with a median score of ≥ 4 [22]. Items meeting these criteria were retained in the final HBPR programme, whereas items not achieving consensus were excluded from the final model.

Intervention Development Framework

The development of the home-based pulmonary rehabilitation (HBPR) programme was guided by established frameworks for complex intervention design to ensure methodological rigor, transparency, and applicability in real-world settings. Specifically, the Medical Research Council (MRC) framework for complex interventions informed the overall development process, while the Template for Intervention

Description and Replication (TIDieR) checklist was used to structure and report the intervention components.

Medical Research Council (MRC) Framework

The development of the HBPR programme was guided by the development phase of the Medical Research Council (MRC) framework for complex interventions. This phase emphasizes the systematic identification and integration of existing evidence, alongside the incorporation of expert knowledge to inform intervention design.

In this study, findings from a prior systematic review were integrated with expert consensus obtained through a modified e-Delphi process to inform the development of the HBPR programme. This approach enabled the identification of core intervention components, the organization of these components into structured domains, and the incorporation of contextual factors relevant to the Jordanian healthcare setting.

This study was limited to the development phase of the Medical Research Council framework, with no feasibility testing or evaluation conducted at this stage. Subsequent phases, including feasibility, evaluation, and implementation, will be addressed in future studies. The application of the development phase is illustrated in Fig. 2.

TIDieR Framework

To enhance transparency and reproducibility, the final HBPR programme was described in accordance with the Template for Intervention Description and Replication (TIDieR) checklist. This framework guided the systematic reporting of key intervention elements, including the rationale, materials, procedures, mode of delivery, provider characteristics, setting, tailoring, and outcome measures.

The application of the TIDieR checklist supports consistent reporting, facilitates replication, and enhances the potential for implementation of the intervention in both clinical practice and future research.

Declarations

Ethical Considerations

Ethical approval for this study was obtained from the Institutional Review Board (IRB) at the University of Jordan (Decision No. 554/2025) and the Research Ethics Committee of Universiti Kebangsaan Malaysia (UKM) (Reference No.: JEP-2025-793). All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and relevant institutional guidelines. Participation was voluntary, and informed consent was obtained electronically from all participants prior to data collection.

Participants were informed of their right to withdraw at any time without consequence. All responses were anonymized, and confidentiality was strictly maintained, with data securely stored and used solely for research purposes.

Informed Consent

Informed consent was obtained from all participants prior to participation in the study.

Competing Interests

The authors declare no competing interests.

Declarations
of Generative AI and AI-Assisted Technologies in the Manuscript Preparation Process

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Author Contribution

E.H.S. conceptualized the study, developed the methodology, conducted the investigation, performed data curation and formal analysis, and drafted the original manuscript. S.M. contributed to conceptualization, methodology, supervision, and manuscript review and editing. N.A.A. contributed to methodology, supervision, and manuscript review and editing. A.A. contributed to investigation and manuscript review and editing. D.K.A.S. contributed to supervision and manuscript review and editing. All authors reviewed and approved the final manuscript.

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CRediT Author Contribution

Enas Hussien Shaltaf: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing – original draft.

Sumaiyah Mat: Conceptualization, Methodology, Supervision, Writing – review & editing.

Nor Azura Azmi: Methodology, Supervision, Writing – review & editing.

Alia Alghwiri: Investigation, Writing – review & editing.

Devinder Kaur Ajit Singh: Supervision, Writing – review & editing.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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Figures

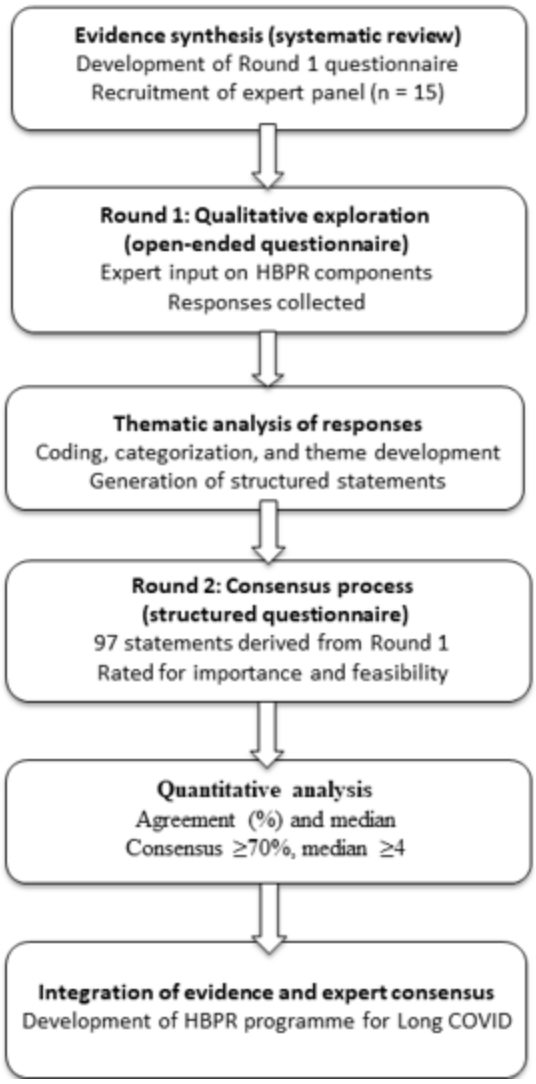


Figure 1

Modified e-Delphi process used to develop the home-based pulmonary rehabilitation (HBPR) programme for individuals with Long COVID. The process included evidence synthesis from a prior systematic review, qualitative exploration through Round 1, thematic analysis of expert responses, generation of 97 structured statements, Round 2 consensus rating, and integration of evidence and expert consensus to develop the final HBPR programme.

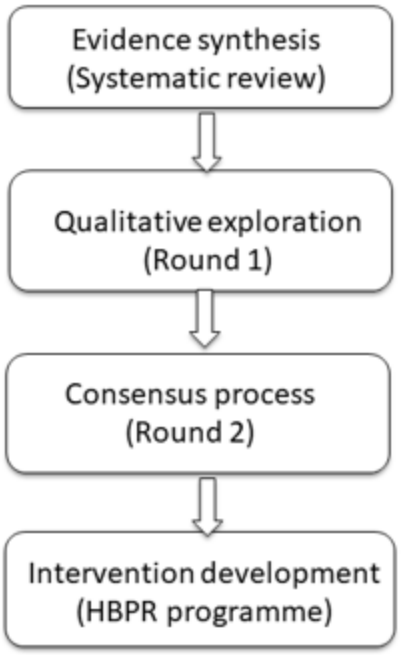


Figure 2

Application of the development phase of the Medical Research Council (MRC) framework in the design of the home-based pulmonary rehabilitation (HBPR) programme for Long COVID. The framework guided the integration of evidence synthesis, qualitative exploration, expert consensus, and intervention development to produce a structured rehabilitation programme.

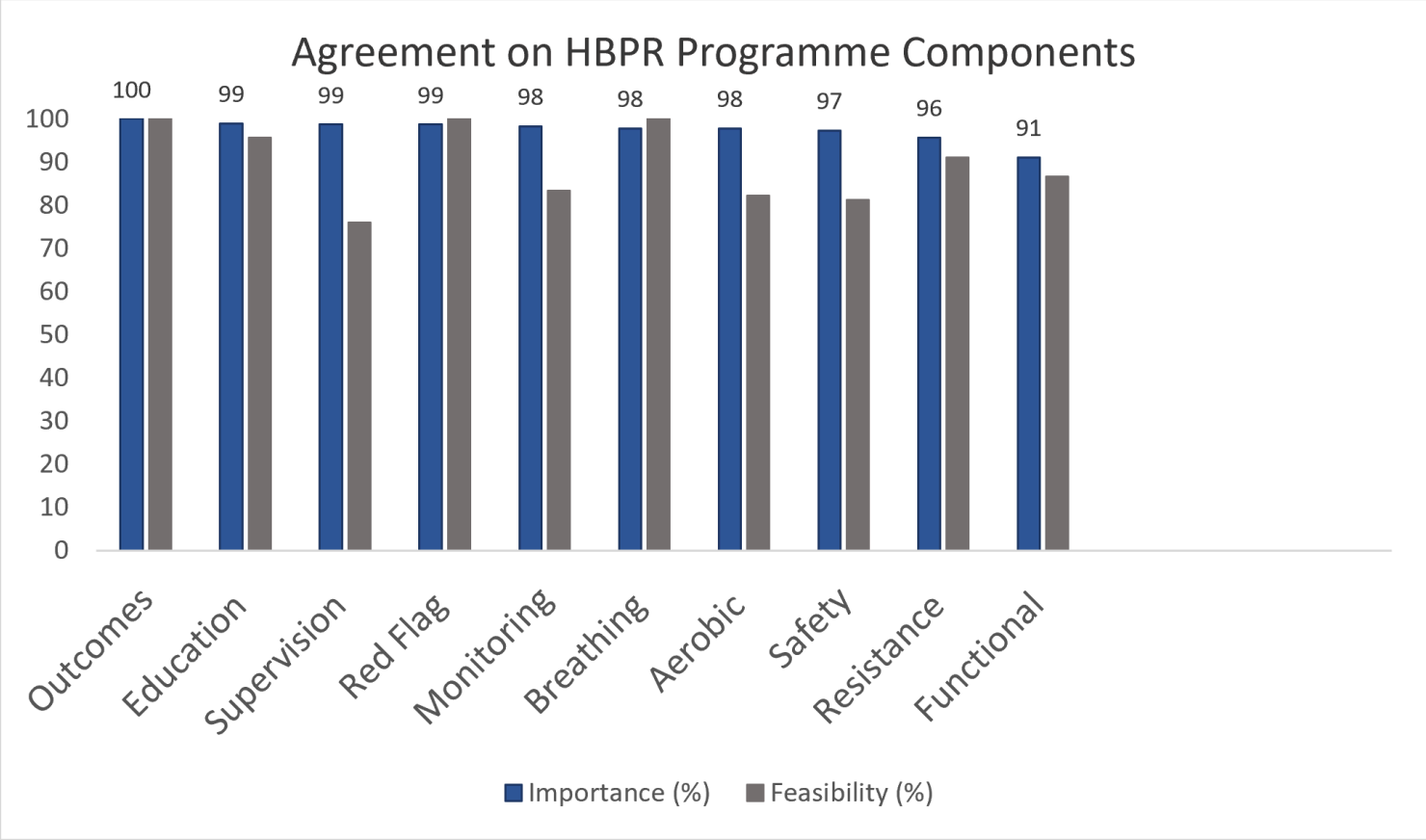


Figure 3

Agreement on home-based pulmonary rehabilitation (HBPR) programme components based on expert ratings of importance and feasibility during Round 2 of the modified e-Delphi study. Values represent the percentage agreement for each programme domain. Higher levels of agreement were generally observed for importance compared with feasibility across most domains.