



# Addressing feasibility challenges to delivering intradialytic exercise interventions: a theory-informed qualitative study

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## ABSTRACT

**Background.** Intradialytic exercise (IDE) may improve physical function and health-related quality of life. However, incorporating IDE into standard hemodialysis care has been slow due to feasibility challenges. We conducted a multicenter qualitative feasibility study to identify potential barriers and enablers to IDE and generate potential solutions to these factors.

**Methods.** We conducted 43 semistructured interviews with healthcare providers and patients across 12 hospitals in Ontario, Canada. We used the Theoretical Domains Framework and directed content analysis to analyze the data.

**Results.** We identified eight relevant domains (knowledge, skills, beliefs about consequences, beliefs about capabilities, environmental context and resources, goals, social/professional role and identity, and social influences) represented by three overarching categories: knowledge, skills and expectations: lack of staff expertise to oversee exercise, uncertainty regarding exercise risks, benefits and patient interest, lack of knowledge regarding exercise eligibility; human, material and logistical resources: staff concerns regarding workload, perception that exercise professionals should supervise IDE, space, equipment and scheduling conflict concerns; and social dynamics of the unit: local champions and patient stories contribute to IDE sustainability. We developed a list of actionable solutions by mapping barriers and enablers to behavior change techniques. We also developed a feasibility checklist of 47 questions identifying key factors to address prior to IDE launch.

**Conclusions.** Evidence-based solutions to identified barriers to and enablers of IDE and a feasibility checklist may help recruit

and support units, staff and patients and address key challenges to the delivery of IDE in diverse clinical and research settings.

**Keywords:** behavior change techniques, hemodialysis, intradialytic exercise, qualitative methods, theoretical domains framework

## INTRODUCTION

Studies assessing the clinical impact of intradialytic exercise (IDE) suggest that ongoing physical activity (e.g. cycling, resistance exercise) during hemodialysis (HD) can mitigate declines in physical function [1–4], lessen the severity and frequency of dialysis-related symptoms (e.g. restless legs, fatigue) [5, 6], increase quality of life [2, 7–9], improve dialysis efficacy [3, 7, 10], protect mental health [3, 8] and improve dialysis-related myocardial stunning [11, 12].

Although growing evidence supports using IDE as an adjunct therapy for individuals on HD, kidney programs have been slow to incorporate exercise into standard care citing feasibility concerns [13–29]. Yet, sustainable exercise programs are possible and stand to generate clinically important outcomes for patients [30].

Current evidence for IDE is primarily limited to small-scale, pilot or single-site trials, with questions regarding scalability and clinical benefit remaining [1]. Larger-scale clinical trials demonstrating the generalizability of improvement in clinical outcomes and the feasibility of IDE programs in resource-diverse locations are required for widespread adoption of this simple, low-cost intervention [31–33].

## KEY LEARNING POINTS

### What is already known about this subject?

- Intradialytic exercise (IDE) is associated with improved physical function, quality of life, dialysis clearance, mental health and, more recently, as a protective factor against myocardial stunning in adults on maintenance hemodialysis (HD).
- Despite these documented benefits, HD units have been hesitant to integrate IDE into standard care, citing concerns over the feasibility of IDE delivery and enactment (e.g. workload, logistics and patient interest).
- Guided by the theoretical domains framework, we sought to identify and consolidate a comprehensive set of potential feasibility barriers and enablers that HD units may encounter when seeking to deliver IDE.

### What this study adds?

- We developed a feasibility assessment tool that provides a checklist of feasibility factors that units are advised to consider before launching IDE interventions.
- While previous studies have focused on providing recommendations for encouraging IDE uptake, we identified barriers and enablers according to the factors known to influence behavior change (theoretical domains) and mapped these factors to theoretically driven strategies (behavior change techniques) to develop fit-for-purpose strategies to support IDE delivery in HD units.
- Using behavior change theory to develop strategies to support IDE delivery and enactment presents those interested in delivering IDE interventions with concrete solutions to overcoming long-standing barriers to IDE (e.g. workload, logistics and patient interest).

### What impact this may have on practice or policy?

- The developed strategies and feasibility checklist can be used together to design unit-specific supportive strategies to address known barriers and enablers across a variety of clinical and research settings.

We conducted a qualitative feasibility study to identify barriers to and enablers of intradialytic cycling from the perspective of healthcare providers and patients across multiple HD units. To facilitate IDE delivery in diverse units we aimed to then identify appropriate behavior change techniques [34, 35], develop actionable solutions and identify key questions that must be considered prior to implementing an IDE intervention in diverse clinical and research settings.

## MATERIALS AND METHODS

We followed the Consolidated Criteria for Reporting Qualitative Studies (COREQ) guidelines [36].

### Sampling strategy

Adults ( $\geq 18$  years of age) with end-stage kidney disease receiving HD and healthcare providers currently working in HD units across Ontario who were able to communicate in English and provide informed consent were eligible to participate in this study. We used both purposive and snowball sampling. We asked program administrators, colleagues and interviewees throughout Ontario to share information about our study. Patients were recruited from four hospital sites and were approached by members of their circle of care. We also placed

an advertisement on the Kidney Foundation of Canada website inviting HD unit staff and patients to contact the research team for information about this study. We sought participants who represented various age groups, geographical regions, unit types (e.g. hospitals, satellite sites), lengths of time in HD units and experiences with IDE.

### Researcher as instrument

G.C., a research coordinator, conducted interviews, analyzed data and drafted this manuscript. G.C. drew from her background in social psychology, the Theoretical

Domains Framework (TDF) and qualitative methods to understand feasibility barriers in context. She deepened her understanding of IDE by engaging with qualitative literature, learning from patient partners and working closely with C.B., a nephrologist and IDE expert. She also received guidance from an expert in health psychology, behavior change and implementation science (J.P.).

### Interview guide development

We used the TDF, a broad and versatile [37, 38] framework that synthesizes constructs from 33 behavior change theories into 12 domains, to facilitate detection of challenges that may arise when IDE interventions are delivered in practice (Table

1). Interview guides were developed based on the action, actor, context, target, time (AACTT) principle and TDF guidance [38, 39]. Questions and prompts were designed to identify barriers and enablers related to the target behavior (i.e. ‘who needs to do what when’) for different stakeholder groups by addressing all 12 TDF domains (see Supplement 1). Interview guides for patient participants were piloted with two patient partners and revised based on their feedback.

### Interviews

Interested participants were invited to participate in a single interview in person (e.g. in a private hospital office) or over the phone. All interviews (phone and in person) were prearranged according to participant availability. The interviewer (G.C.) had no prior relationship with participants and explained the goals of the study (i.e. to identify barriers to and enablers of supporting and engaging in intradialytic cycling). Interviews were digitally recorded with permission. G.C. took notes during and after interviews, capturing key ideas, tone and reflections. Interviews were transcribed verbatim by a professional transcriptionist. Interview quotes were shared with participants when specifically requested. Interview transcripts were not shared with participants for feedback.

### Analysis

We conducted a directed content analysis guided by the TDF and facilitated by NVivo version 11 (QSR International, Chadstone, VIC, Australia) [38, 40]. G.C. read through transcripts, identified data units (between two and six lines of text), labeled data with codes and sorted codes into TDF domains. Codes were refined by comparing data units within and across codes to determine how codes were similar, different and related to each other. Codes relating to similar topics were grouped into within-domain subcategories. Code and subcategory definitions were documented in a codebook.

A second analyst (M.W.) with a background in public health independently coded nine interviews and assessed how well the codebook captured the data. The two analysts discussed

competing interpretations of codes and subcategories until they arrived at agreed-upon changes to the codebook. M.W. coded an additional six interviews and independently generated analytic categories that transcended domains. The two analysts met to discuss their respective analyses.

In parallel, patient partners were provided with results tables that featured brief descriptions of domain-level subcategories along with representative quotes. Patient partners were invited to provide feedback and insights on the results tables in two meetings. G.C. integrated feedback from all sources to develop the final set of analytic categories.

### Saturation

We used the 10 + 3 saturation rule to verify that no new within-domain subcategories were identified in the last three interviews for each stakeholder group (i.e. healthcare providers and patient interviews) [41].

### Developing solutions to identified barriers

G.C. and M.W. used existing tools [34, 35] to independently map TDF-identified barriers (i.e. cross-domain categories) to behavior change techniques (i.e. components of an intervention that target behavior change) [34] to facilitate developing fit-for-purpose strategies for supporting IDE engagement and delivery in HD units with diverse characteristics. G.C. and M.W. discussed differences until they reached consensus regarding what behavior change techniques were most suitable.

### Feasibility assessment tool

We developed an IDE feasibility assessment tool to aid in the identification of unit-specific factors that need to be identified and addressed prior to the launch of an IDE cycling intervention (Box 1). Questions were generated by considering what barriers and enablers varied across represented units.

### Ethics

This study received ethics approval from the Ottawa Health Science Network Research Ethics Board (protocol

**Table 1. Description of theoretical domains included in the TDF version 1 [37, 38]**

Domain	Description
Knowledge	An awareness of the existence of something (including knowledge of condition/scientific rationale)
Skills	An ability or proficiency acquired through practice
Social/professional role and identity	A coherent set of behaviors and displayed personal qualities of an individual in a social or work setting
Beliefs about capabilities	Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use
Beliefs about consequences	Acceptances of the truth, reality or validity about outcomes of a behavior in a given situation
Motivation and goals	Mental representations of outcomes or end states that an individual wants to achieve
Memory, attention and decision processes	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives
Environmental context and resources	Any circumstance of a person’s situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behavior
Social influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings or behaviors
Emotion	A complex reaction pattern involving experiential, behavioral and physiological elements by which the individual attempts to deal with a personally significant matter or event
Behavioral regulation	Anything aimed at managing or changing objectively observed or measured actions
Nature of behavior	Direct experience/past behavior including routine, automatic or habitual behavior

## Box 1. Feasibility tool for introducing IDE into a given unit

### Knowledge, skills and expertise

What training can be provided to existing unit staff?

- Are the unit leadership aware of current evidence for IDE?
- How will risks and benefits of IDE be communicated to staff and patients?
- Do staff have the capacity to undertake skills training?
- Do staff have the capacity to employ learned skills?
- What kind of support can be provided at the bedside?
- What guidance will be provided to aid staff in identifying patients?
- Will rationales for inclusion/exclusion criteria be provided?
- What experience do staff have with exercise equipment and IDE interventions?
- Will staff be trained to conduct assessments and how to make adjustments to exercise plans?

What expertise do unit staff have access to?

- Will the unit have access to an exercise professional?
- Will an exercise professional be available to set up the intervention?
- Will an exercise professional deliver the intervention?
- Who will deliver the intervention beyond the trial?
- Will staff support the IDE intervention if the unit has access to an exercise professional?

### Human, material and logistical resources

What kind of unit (academic, community and satellite) is being considered for an IDE intervention?

- Do they have a history of previous IDE programs?
- How often are nephrologists present in the unit?
- What is the inpatient:outpatient ratio?
- What is the nursing staff:patient ratio?
- What does a typical nurse assignment involve?

What staff are available to contribute to an IDE program?

- Is now a good time? How saturated is the unit with other ongoing practice changes?
- How much time do staff feel they have to devote to another practice change?
- How do staff characterize their workload?
- What is the current division of labor and how do staff feel about it?
- Are there dialysis aides, personal support workers, exercise professionals, students or volunteers available?

What equipment is present in the unit?

- What equipment, if any, is available (e.g. what bike models)?
- What are staff and patient perceptions of existing exercise equipment? Does equipment need to be replaced or supplemented?
- Will the chosen equipment interfere/conflict with dialysis setup (e.g. will the bike model preclude the use of certain bed/chair models)?
- How are patients assigned to chairs/beds? How will this impact equipment set up?
- How will incompatible equipment be addressed?

How will the layout of the unit impact exercise set up?

- How far away are potential equipment storage areas?
- How much time is needed to retrieve equipment?
- Is there sufficient space for equipment to be moved around (e.g. bikes to be wheeled around in a cart)?

When is the best time to set up exercise equipment?

- How are staff breaks organized?
- How much time is equipment set up expected to take?
- How can the time needed to set up equipment be integrated into the daily flow of unit activities?

## Social dynamics of the unit

What is the likelihood of engaging champions?

- Are there easily identifiable champions in the unit's leadership team? Among frontline staff? Among patients?
- Does the unit leadership have the capacity to support a new intervention?
- Do nephrologists support IDE? Are they willing to endorse and champion an IDE intervention?
- Will frontline staff champions be allocated time to complete champion-related tasks?
- What training do champions need to complete their champion duties?
- How socially engaged are champion contenders? How likeable are champion contenders?

What communication avenues are available for sharing patient stories and outcomes?

- What patient stories can be shared with unit staff and other patients?
- What opportunities are there for showcasing patients who exercise?
- What kind of intervention progress and outcome data can be shared with staff and patients?
- How can feedback mechanisms be integrated into the intervention?

20180517-01T; Clinical Trials Ontario 1526). All participants provided written or verbal consent prior to participating in interviews.

## RESULTS

### Participants

Thirty-five healthcare providers and 27 patients expressed interest in completing an interview. Of those, six healthcare providers and six patients could not be reached, three healthcare providers and two patients declined for unknown reasons and two patients declined due to health changes. Forty-three interviews were conducted between September 2018 and February 2020, including 26 healthcare providers (8 nurses, 7 nephrologists, 6 managers, 3 exercise professionals and 2 unit aides) and 17 patients across 12 hospital hubs in Ontario, Canada (see Table 2 for participant details).

**Healthcare providers.** More women-identified healthcare providers ( $n = 18$ ) participated than did men. The median age of staff was 45 years [interquartile range (IQR) 35–52]. They reported working in HD units for a median of 10.5 years (IQR 4.5–18.5). Most staff were based in teaching hospital units ( $n = 18$ ) and many had prior experience with intradialytic cycling programs ( $n = 12$ ). Most interviews with staff were conducted over the phone ( $n = 24$ ) and lasted a median of 34.5 min (IQR 31–42).

**Patients.** Eight women and nine men participated in interviews. The median age of participants was 57 years (IQR 51.5–68). Participants had been on maintenance HD for a median of 5 years (IQR 3.5–7). Many were based in teaching hospital units ( $n = 9$ ) and seven had experience cycling while dialyzing. Fourteen interviews were conducted over the phone and three were conducted in person. Interviews lasted a median of 43 min (IQR 34–59). One interview was conducted in an HD unit where staff and other patients were present. Interviews with

healthcare providers and patients that were conducted over the phone were similar in content, length and tone as those conducted in person. Participants who were interviewed in person were recruited from the same site but did not differ otherwise from those interviewed over the phone.

### Categories and relevant domains

We identified eight TDF domains as critical to address given their relevance, strength and frequency [38] (knowledge, skills, beliefs about consequences, beliefs about capabilities, environmental context and resources, goals, social/professional role and identity, and social influences). Three analytic categories summarize cross-domain categories: knowledge, skills and expectations; human, material and logistical resources; and social dynamics of the unit. Table 3 presents the analytic categories, cross-domain categories, relevant domains and exemplary quotes. All participant names have been replaced with participant-chosen pseudonyms.

#### Category 1: knowledge, skills and expectations

**Risks and benefits for staff and patients.** Staff and patient interviewees believed patients would experience positive health outcomes (e.g. improved cardiovascular, mental and physical health, quality of life and dialysis clearance) and that IDE was a productive use of time, though some remained skeptical of the potential benefits. Staff and patients simultaneously expressed concerns over potential risks, fearing an increase in symptoms like fatigue and cramping, negative impacts on cardiovascular health and the risk of equipment interfering with timely crisis intervention.

**Insufficient skill to create and oversee exercise plans.** Interview participants were concerned about exercise-related injuries, given that staff lacked the expertise to develop and oversee individualized exercise plans. Staff were uncertain regarding contraindications to exercise participation. Staff



**Table 2. Participant characteristics**

Characteristics	Healthcare providers ( <i>n</i> = 26)	People on dialysis ( <i>n</i> = 17)
Gender, <i>n</i>		
Women	18	8
Men	8	9
Age (years)		
Mean (SD)	43.5 (10.03)	57.7 (12.53)
Median (range)	45 (28–59)	57 (32–79)
IQR	35–52	51.5–68
Years in/on HD		
Mean (SD)	11.5 (8.59)	7.3 (6.22)
Median (range)	10.5 (1.5–33)	5 (2–24)
IQR	4.5–18.5	3.5–7
Type of unit <sup>a</sup>		
Teaching hospital unit	18	9
General hospital (>100 beds)	4	2
General hospital (<100 beds)	1	1
Teaching hospital satellite site	3	5
Experience with IDE		
Yes	12	7
No	14	10
Interview length (min)		
Mean (SD)	37.75 (9.65)	47 (18.45)
Median (range)	34.5 (25–73)	43 (19.5–93)
IQR	31–42	34–59
Place of interview		
Over the phone	24	14
Hospital/office	2	3

<sup>a</sup>Units were classified based on the Ontario Ministry of Health's classification system (<http://www.health.gov.on.ca/en/common/system/services/hosp/hospcode.aspx>).

suggested they would benefit from in-servicing and expert oversight to safely adjust care plans.

**Assumptions about patient eligibility.** Staff expressed uncertainty regarding eligibility criteria and expressed beliefs that patients who were hemodynamically unstable, older, frail and experienced limited mobility would not be appropriate candidates for IDE. Some suggested they would be inclined to approach healthier patients first. A few patient participants echoed similar beliefs. One nephrologist believed staff assumptions regarding patient eligibility may unnecessarily limit who benefits from an IDE intervention.

**Assumptions about patient interest.** Staff and patients expressed skepticism regarding the feasibility of IDE given their perceptions of low patient interest. Staff and patients believed that eligible patients would rather use their dialysis time to rest and only a few patients (e.g. 20–30%) would be interested in cycling.

**Identifying and approaching potential candidates.** In units where cycling was available, identifying candidates was often left to the discretion of individual unit staff. Some staff reported approaching patients who demonstrated mobility, stamina and motivation. Others relied on patients to self-refer. However, several patient participants who expressed interest in intradialytic cycling during their interview reported they had not asked about using bikes available in their unit because they preferred to be approached by staff. Some were concerned that asking staff may be bothersome ('It might be a pain in the ass to

set up, you know what I mean?' – Robert), while others were unsure whether cycling was appropriate for them. One patient participant suggested being asked by staff to cycle may motivate engagement.

## Category 2: human, material and logistical resources

**Concerns about workload.** Staff believed introducing an IDE intervention would significantly increase workload, though a few believed the workload would lessen in the long term as patients improved their functional status (e.g. fewer patients needing staff-assisted transfers). Staff indicated the unpredictability of HD sessions made it challenging to prioritize bike set up, even when IDE was viewed favorably. Nursing staff resented delegation of tasks perceived as extraneous to their scope of practice without consideration for how that might impact their work experience. Many suggested delivering IDE cycling programs would be difficult given their time constraints and used the refrain 'one more thing' to emphasize strained resources. A few based their workload expectations on past experiences where cyclists were described as 'a pain in the butt' when exercise-related movements set off alarms during treatment, while another staff member from the same unit believed delivering IDE was manageable despite time constraints. Others believed there was sufficient time for bike set up in their units.

**Need for exercise professionals.** In units that previously had exercise programs run by physiotherapists, staff participants believed IDE was part of an exercise specialist's role and not their's. Others believed that exercise specialists were the

**Table 3. Global themes, TDF domains and exemplary quotes**

Subcategories	TDF domains	Quotes
<p>Category 1: knowledge, skills and expectations</p> <ul style="list-style-type: none"> <li>• Risks and benefits for staff and patients</li> <li>• Most believed IDE was associated with a variety of health benefits</li> <li>• A few expressed doubts over benefits</li> <li>• Many raised concerns over risk of injury</li> </ul>	<p>Beliefs about consequences Knowledge</p>	<p>‘So, I say you get more energy, more flexibility. Your legs move better, you know. You can go up the stair without feeling like you climb a mountain, you know’. – Marlena, patient</p> <p>‘And so I think if they could get in an exercise program and hopefully get stronger in order to better prepare them for transplant I would be excited for that patient’. – Anne, MD</p> <p>‘So intradialytic exercise has been shown to improve certain patient symptoms like restless legs, for example. That’s the one that I believe may be true. There’s a bunch of other stuff that intradialytic exercise has been named to improve, like in terms of outcomes like depression, blood pressure, ultrafiltration, but I’m not sure I believe any of those other stuff, so maybe restless legs’. – Sam, MD</p> <p>‘Because when you’re on the machine you get very sick and you get light-headed and your blood pressure drops and, you know, it’s not easy, trust me, it’s not an easy thing. Yeah it’s very rough. Yeah so I wouldn’t want to take a chance’. – Sandra, patient</p> <p>‘Yeah the only issue that I see with that is in the off chance of an emergency, you know, your blood pressure bottoms out or because you’re pedalling and everything your heart rate will be a little bit higher, right’. – Ian, patient</p>
<ul style="list-style-type: none"> <li>• Insufficient skill and knowledge to create and oversee exercise plans</li> <li>• Staff questioned what factors precluded exercise</li> <li>• Staff believed they lacked the necessary skill and training to oversee exercise plans</li> </ul>	<p>Skills Knowledge</p>	<p>‘I think just the plan. . . what the expectations would be in terms of the exercise? So how they’re gonna progress the first few weeks or what the intention is? . . . what’s an absolute contraindication to the study? What’s something that we can modify? We would certainly need that information’. – Trish, RN</p> <p>‘And it’s not just randomly pedalling without a clear goal or expectation. I think that’s the part where nurses, technicians and doctors even nephrologists don’t really have a lot of expertise in. And so, you know, if you just bring pedals to a unit and you say here you go that’s where you’re likely gonna fail because we lack that ability to really assess and tailor the programs to patients individually’. – Justin, MD</p>
<ul style="list-style-type: none"> <li>• Assumptions about patient eligibility</li> <li>• Staff raised questions regarding eligibility criteria and contraindications</li> <li>• Both staff and patients believed people who were older, frail and with limited mobility were unlikely to be eligible for IDE</li> <li>• One staff participant believed assumptions about eligibility may lead to missed opportunities</li> </ul>	<p>Beliefs about consequences Knowledge</p>	<p>‘It depends on the patient but I think if I had a patient that I knew was having a lot of angina or I needed to intervene with and do ECGs on a regular basis I’d probably say that’s somebody I don’t think should exercise. But is that really true?’ – Molly, RN</p> <p>‘Usually the mobile patient is offered first, right, the people, the patients that walk in. The people that come in in wheelchairs and so forth are, you know, assessed by physio and, and that sort of thing. And then the ones that we know that tend to drop their blood pressure during dialysis are not offered. But usually the ones that walk in, you know, independently the younger patients’. – Susy, RN</p> <p>‘It depends on their health state and depends on their age too. Age matters if you are very old, some people are very old there so I don’t believe those people can do the exercise’. – John, patient</p> <p>‘Sounds great but I think the crowd that I’m with, a lot of them come in walkers. Some come in the little carts so, in my personal view, if you got 20% of us you did very well’. – Robert Redford, patient</p> <p>‘Yeah I think your biggest challenge, on the medical side, your challenge is making sure that we don’t, that doctors or nephrologists don’t make patients ineligible when in fact they might stand to benefit. I think that’s the biggest risk from a medical standpoint’. – Justin, MD</p>
<ul style="list-style-type: none"> <li>• Assumptions about patient interest</li> <li>• Staff and patients believed few eligible patients would be interested in IDE</li> </ul>	<p>Beliefs about consequences</p>	<p>‘I think for certain patients who are keen to do it and are going to do it on an ongoing basis. . . unfortunately I don’t think there’s a lot of them. . .’. – George, MD</p> <p>‘People just want to come in either turn on the TV or come in and have a nap. So, it’s a smaller percentage of patients that really want to participate while they’re on dialysis’. – Jane, manager</p> <p>‘Oh I think the exercise thing is awesome but I think it will be a bit of a challenge to get some patients to agree. There’ll be patients there’ll be a handful of patients that will be quite willing, but there’ll be some patients that we’ll need to persuade a little bit . . . But it’ll be challenging for sure looking at our group’. – Shelby, RN</p>

*Continued*

Table 3. Continued

Subcategories	TDF domains	Quotes
<ul style="list-style-type: none"> <li>Identifying potential candidates</li> <li>Some staff relied on patients to self-refer</li> <li>Some patients preferred to be approached by staff</li> </ul>	Social and professional role Knowledge	<p>‘So you’re coming in there with an exercise machine into an environment that is not used to it you’re gonna have a very big uphill battle. For me personally it’s wonderful, but for my surrounding people, my peers, I think you’re gonna have a terrible time’. – Callie, patient</p> <p>‘I don’t think there’s anybody that would like to bother them about exercise. . .’. – Jennifer, patient</p> <p>‘I guess if I saw value in it I would suggest it to a patient like patients who feel that they have restless legs or patients complain of other things, like being bored. I might say why don’t you try the cycling program? Typically, though, the patients ask us. I have to admit I’m probably not as good at suggesting it as I am at supporting it if someone asks’. – Molly, RN</p> <p>‘So for now it’s still on a voluntary basis so if any patients see the other patients exercising they can approach me or the nurses. Otherwise sometimes the doctors will refer them to me’. – Tina, exercise professional</p> <p>‘If they have someone that would ask you if you want to do exercise rather than waiting for you to ask <i>them</i>, it might motivate more people’. – Lola, patient</p>
Category 2: human, material and logistical resources <ul style="list-style-type: none"> <li>Concerns about workload</li> <li>Participants believed an IDE intervention would significantly increase staff workload and would be difficult to prioritize</li> <li>Perceptions of workload may be influenced by past experiences</li> <li>Many believed nursing staff would be resistant to more work</li> <li>A few believed workload may lessen</li> </ul>	Beliefs about consequences Beliefs about capabilities Environmental context and resources Goals	<p>‘. . .so they’re like all over the place trying to cover each other and stuff like that. So I’m just wondering how that’s gonna affect somebody coming in to just stay with me while I do those exercises. . .’. – Guinea Pig, patient</p> <p>‘The other thought though is the impact on the staff. Because someone on the staff has to bring the bike put it in place, move it away, and depending on what the mechanics and logistics are that’s an added workload for the staff and that’s got to be factored in for sure’. – Sheldon, patient</p> <p>‘I think that staff are already very, very busy and to throw something else at them I think will get an emotional response. There’ll be resistance based on workload’. – Penelope, manager</p> <p>‘. . .all you need is one of those patients to have a line that doesn’t work, a fistula that’s acting up or somebody that’s unwell and your whole day goes to hell in a handbag. So having to drag somebody’s physio equipment on top of it, you know, it’s just kind of one more thing to a never-ending list. But in that particular instance it’s not gonna get done because the priority is the sick patient, a line that doesn’t work’. – Amy, RN</p> <p>‘. . .while the patient’s actually dialysing there is downtime so that’s there’s opportunity for the staff to step in there and set up the equipment have the conversations with the patient. So I can’t really see it being an extra workload for anybody’. – Elizabeth, manager</p>
<ul style="list-style-type: none"> <li>Need for exercise professionals</li> <li>Many participants believed exercise professionals should take responsibility for IDE to address workload concerns</li> <li>One participant shared how nursing staff were resistant to IDE even when an exercise professional was present</li> </ul>	Social and professional role Environmental context and resources	<p>‘Yeah that model [with physiotherapists] would be I think the better than just leave it for the nurses if there’s just one person comes and set it up and it would be some, it would be some resource accessible to the nurses too. They’re just not leaving the nurses with some kind of extra work to be done yeah’. – Sarah, RN</p> <p>‘And I think that somebody with exercise expertise who could transmit that and then you get into the champions idea so that there are people who know who have a better understanding of what’s going on. I think that would work best’. – Sue, MD</p> <p>‘Well the advantage of the physiotherapist was guidance’. – John Doe, patient</p> <p>‘So I think there was a lack of knowledge from the beginning on the nursing staff and a lot of resistance. So, you know, the fact that I was touching their patients I think that was a huge issue at the beginning’. – Tina, exercise professional</p>
<ul style="list-style-type: none"> <li>Space and equipment</li> <li>Units differ in space requirements for bike storage and movement</li> <li>Biking equipment must fit dialysis chair/beds and be easy to move, use, maintain and clean</li> </ul>	Environmental context and resources	<p>‘. . .if we have several bikes that are being used at a time it creates more equipment that could be tripped over or if we have someone who’s unstable and we had to call a code it’s just more equipment that could be in the way’. – Maddie, RN</p> <p>‘We’d have to wait until all the patients are on because the nurses are moving around and patients are coming and going and we don’t want anything on the floor to be in their way. So we’d have to wait until they were all on’. – Stephanie, unit aide</p> <p>‘[And] the cleaning of those things too. Like okay, if this thing comes off you can just put this thing back in or if this thing is loose you can tighten</p>

Continued



Table 3. Continued

Subcategories	TDF domains	Quotes
<p>Category 3: social dynamics of the unit</p> <ul style="list-style-type: none"> <li>• Champions</li> <li>• Champions are important enablers of IDE</li> <li>• Nephrologists were believed to be instrumental in supporting practice changes</li> <li>• Nurse champions were seen as necessary for supporting practice changes at the bedside and encouraging patients to cycle, though many suggested it would be difficult to recruit nurse champions</li> <li>• Patient champions were believed to encourage other patients, though not all patients would welcome a peer champion</li> </ul>	Social influence	<p>it from here or if this thing is making noise we can put oil here. So, those are some small things we need to know and that way we can run this program smoothly'. – Afim, unit aide</p> <p>'The nurses don't like having to move that bike around so they don't encourage it...the nurses don't because frankly they don't like having to lug it out and move it around. That's my honest impression. [laugh]' – Brian, MD</p> <p>'I think the biggest trouble that I've had is logistics... is the right patient on the right bed for their session?...if you're on the wrong bed I can't bike with you'. – Edward, exercise professional</p> <p>'I've been back on dialysis for over two years and there's nothing... nobody seems to know where there's a bike'. – Marie, patient</p>
<ul style="list-style-type: none"> <li>• Patient stories to ignite motivation</li> <li>• Patient stories and experiences are highly influential and can motivate staff and patients to engage in IDE</li> </ul>	<p>Social influence</p> <p>Goals</p>	<p>'... it would need to be the physiotherapist and somebody from the administration side... then one of the physicians as well. So having at least one physician champion would be very helpful as well'. – Nurse, manager</p> <p>'And having the physicians onboard too and maybe them coming to talk to the staff about it is another one'. – Veronica, RN</p> <p>'Just maybe the staff pushing a little bit more, you know, just trying to talk you into it without being too pushy. You know, just reminding you that the equipment's there and how good you felt when you were on it'. – Bandit, patient</p> <p>'I think it's a good idea. But I don't know... Just like from my time as charge nurse and then the coordinator saying, you know, get somebody on this, get somebody on this and never would you have anybody volunteering for things'. – Lou, RN</p> <p>'Well it can only be a positive thing, because you have a champion helping you, encouraging you that's got to be a positive thing'. – Susy, patient</p> <p>'I think the staff going to patients and saying that we think...the cycling program is for you and it will help you. Patients would react to that a certain degree more so than if oh these three people are involved...'. – Timbo Slambo, patient</p> <p>'Speaking only for myself, I think I'd find it an unnecessary pressure'. – Sheldon, patient</p> <p>'And then the other side would be patient stories. Any patients that have had the intradialytic exercise and what it means to them and the benefits of it...If you've got some of that I think that would help'. – Polly Anna, manager</p> <p>'I guess the feedback from the patients that they're enjoying it. If it becomes important to the patient, then it becomes important to me'. – Lou, RN</p> <p>'... if the patient's excited about it it's gonna be a lot harder to say no we're not doing that for you'. – Trish, RN</p> <p>'This lady in the article, she was the one who was biking back then. I don't know what year that was when her picture was taken...And she was in there and I thought if she can do it I can do it'. – Canadian Kidney Girl, patient</p>

most qualified healthcare providers and preferred they oversee an IDE program, including bike set up. A few patient participants indicated they would appreciate the oversight and monitoring of an exercise professional, though others believed this was not necessary. One staff participant shared that an exercise professional in their unit was met with staff resistance while other staff expressed interest in offering exercise opportunities without the guidance of an exercise specialist.

**Space and equipment.** Staff believed exercise bikes would increase clutter in the unit and interfere with unit processes. They suggested grouping cyclists in low-traffic areas to

minimize moving equipment and thereby reduce collisions. Participants also discussed the need for exercise bikes to be light, mobile, easy to set up, easy to maintain and clean, easy to adjust to patient stature and compatible with existing HD chairs and beds. For several participants, access to the right type of equipment was the most significant barrier faced in their unit. One staff participant suggested learning basic bike repairs would be necessary for long-term sustainability. Some staff suggested improving patient scheduling to ensure they were dialyzing in chairs suitable for cycling. A few patients indicated that exercise bikes that were quiet would be important to ensure harmony in the unit.

### Category 3: social dynamics of the unit

**Champions.** Participants identified administrative, frontline and patient champions as critical enablers for the delivery and sustainability of IDE. Staff and patient champions were thought to generate change through their knowledge, passion, dedication and positive relationships with others in the unit.

Staff agreed that nephrologists' endorsements would persuade nursing staff that an IDE intervention would be worth the effort. Patient participants indicated they would be more likely to engage in IDE if their nephrologist recommended it.

Nurse champions were seen as critical for teaching, modeling practice changes and offering support to their peers. Staff and patients believed nurse champions were well suited to promoting exercise given their involvement in the routine care of patients. However, nursing staff believed it would be difficult to find volunteers for the champion role. One nurse suggested that having dedicated time, or a financial incentive, to take on a champion role would help generate interest.

Patient champions were seen as helpful for encouraging other patients to cycle. Patient participants shared that they would feel encouraged to engage in IDE if they could see the process modeled by others first. However, many noted that not all cyclists would appreciate a peer mentor and may instead prefer guidance from healthcare staff. Patient participants also varied in their interest in adopting a champion role depending on how socially engaged they were in the unit.

**Patient stories.** Staff and patients viewed patient stories as a powerful enabler. Staff participants valued improving patient experiences, outcomes and quality of life and expressed a desire to see patients 'do well'. Frontline staff indicated that they would be more motivated to set up bikes if they knew it would result in health improvements for patients and if they knew IDE was important to patients ('if it becomes important to the patient, then it becomes important to me' – Lou, nurse). Patient participants were also influenced by patient stories and experiences. Many described becoming interested in IDE after seeing or hearing about other patients using exercise equipment during dialysis.

### Actionable solutions to identified barriers

The barriers and enablers identified in this study were mapped to behavior change techniques and operationalized based on details provided in participant interviews (see [Table 4](#) and [Supplement 2](#)). For example, participant concerns regarding risks and benefits and how to oversee exercise plans were rooted in a lack of knowledge and skills and associated expectations. Using behavior change techniques that provide opportunities for learning and skill development (e.g. instruction on how to perform the behavior, demonstration of the behavior, information about health consequences) and that encourage critical evaluations of risks and rewards (e.g. information about health consequences, comparative imaging of future outcomes, pros and cons) may address staff and patient apprehension, thereby encouraging staff engagement in IDE delivery and patient enactment of IDE.

### Feasibility assessment tool

The identified behavior change techniques may help to facilitate IDE delivery across diverse settings. However, identifying which solutions are most appropriate for a given unit will depend on specific local barriers and enablers. For example, staff perceptions of workload varied across and within units, suggesting a need to assess how staff view their current workload (e.g. 'How do staff characterize their workload?') prior to intervention launch. [Box 1](#) presents key questions regarding each of the identified factors that researchers, clinicians and unit managers can use to evaluate unit readiness and to identify which solutions are most appropriate for addressing anticipated barriers before moving forward with program delivery in both research and clinical settings.

## DISCUSSION

Many have suggested that integrating IDE into standard care requires a change in dialysis culture toward wellness rather than medical treatment [30, 33]. Although definitions vary, 'culture' can be understood to encompass shared values, behaviors, goals and assumptions [42, 43]. The proposed behavior change techniques and operationalized solutions target values, behaviors, goals and assumptions. Thus this work builds upon past research by suggesting a means by which to operationalize culture change and increase the feasibility of IDE. Our tools, grounded in behavior change theories, provide actionable solutions to identified barriers and are designed to facilitate the delivery of IDE programs in clinical practice and multisite clinical trials.

Past research reporting on barriers to IDE has found similar barriers and enablers as those identified in this study. Staff workload has been a recurring barrier to IDE without clear solutions [14, 15, 18, 20–23, 29]. Our study confirms that workload and time constraints are challenging factors. However, the differences in workload perceptions among staff in this study nuance our understanding of these barriers by highlighting how 'anticipated' workload (based on assumptions or negative past experiences) differs within and across units, suggesting staff attitudes may be shaped, in part, by expectations. Recent research supports this association, as one study found that nursing staff who had not witnessed patients exercising were more likely to identify barriers while those who had seen patients exercising expressed more positive views [44]. Another study found that staff expressed more positive views after watching an IDE film and gaining a better understanding of how intradialytic cycling operates [45]. Staff expectations therefore represent a potential avenue for change in addition to seeking organizational support to bolster human resources.

Patient eligibility and interest have also been previously identified as barriers [4, 14, 20, 22, 29, 46]. Yet, almost anyone can exercise so long as they begin with low intensities and gradually progress [46]. Likewise, evidence herein and in the literature [17, 24, 25, 46] suggests patient interest may not be as significant a barrier as staff perceptions suggest [20, 31]. It is possible that patients refrain from expressing interest if they are uncertain about their eligibility and may instead rely on staff to provide clarity. Behavior change techniques that target staff and

Table 4. Suggested behavior change techniques to improve the feasibility of IDE interventions

Barriers/enablers	TDF domains	Suggested behavior change techniques	Suggested operationalization/activities
Knowledge, skills and expectations Uncertainty about risks and benefits	Knowledge/beliefs about consequences	Information about health consequences <i>Provide information (e.g. written, verbal or visual) about health consequences of performing the behavior</i>	Providing staff and patients with accessible (e.g. written and visual) information about known risks and benefits of engaging in IDE
	Beliefs about consequences	Comparative imagining of future outcomes (of changed versus unchanged behavior) <i>Prompt or advise the imagining and comparing of future outcomes of changed versus unchanged behavior</i>  Pros and cons <i>Advise the person to identify and compare reasons for wanting (pros) and not wanting to (cons) change the behavior</i>	Providing staff and patients with comparative data demonstrating expected health outcomes associated with engaging and not engaging in IDE and how these might apply to themselves  Facilitate discussions with health care providers, patients and exercise specialists to highlight the benefits/gains of engaging in IDE versus not engaging in IDE
Lack of knowledge and skill to develop and oversee exercise plans	Knowledge	Instruction on how to perform the behavior <i>Advise or agree on how to perform the behavior (includes 'skill training')</i>	Providing staff training that explains expected progress trajectories (addressing knowledge) and provide specific steps on how to develop, execute and modify individualized exercise plans with examples
	Skills	Demonstration of the behavior <i>Provide an observable sample of the performance of the behavior, directly in person or indirectly (e.g. via film, pictures) for the person to aspire to or imitate</i>	Provide staff with examples (e.g. a short video) of how to develop and execute a basic exercise plan, including how to make adjustments to meet patient needs and abilities and ensure patient safety
Assumptions about patient eligibility	Knowledge	Information about health consequences <i>Provide information (e.g. written, verbal or visual) about health consequences of performing the behavior</i>	Provide guidelines/information about patient attributes that would and would not allow for engagement in IDE, with an emphasis on addressing eligibility misconceptions (e.g. frailty not a contraindication)
	Beliefs about consequences	Credible source <i>Present verbal or visual information from a credible source in favor or against the behavior</i> Saliency of consequences <i>Use methods specifically designed to emphasize the consequences of performing the behavior with the aim of making them more memorable (goes beyond informing about consequences)</i>	Invite IDE experts to discuss the merits of adopting inclusive eligibility criteria  Present memorable cases of patients who benefited from IDE that might not otherwise be believed to be eligible

Continued

**Table 4. Continued**

Barriers/enablers		TDF domains	Suggested behavior change techniques	Suggested operationalization/activities
Assumptions about patient interest	Beliefs about consequences		Information about others' approval <i>Provide information about what other people think about the behavior. The information clarifies whether others will like, approve or disapprove of what the person is doing or will do</i>	Provide unit with research evidence and local indications of patient interest in an IDE program
Identifying potential candidates	Social and professional role		Restructuring the social environment <i>Change or advise to change the social environment in order to facilitate performance of the wanted behavior</i>	Encouraging patients to take on a more active role by requesting bike use when appropriate Senior staff may also delegate the responsibility of identifying potential candidates to specific staff to ensure consistency
Human, material and logistical resources Concerns about workload	Goals		Action planning <i>Prompt detailed planning of performance of the behavior (must include at least one of context, frequency, duration and intensity)</i>	Work with local nursing staff to develop a when, where and how plan for how bike set up can be prioritized alongside competing demands (e.g. set up bikes 10 min before I go on break)
	Beliefs about consequences		Information about social and environmental consequences <i>Provide information (e.g. written, verbal and visual) about social and environmental consequences of performing the behavior</i>	Provide information about the consequences of implementing an IDE program in the HD unit (i.e. in terms of work flow, time needed to set up bikes and impact on environment)
	Environmental context and resources		Social support (practical) <i>Advise on, arrange, or provide practical help (e.g. from friends, relatives, colleagues, buddies or staff) for performance of the behavior</i>	Hire/schedule additional HD staff to deliver the IDE program. This may include nursing staff, personal support workers, unit aides, students and volunteers
	Beliefs about capabilities		Behavioral practice/rehearsal <i>Prompt practice or rehearsal of the performance of the behavior one or more times in a context or at a time when the performance may not be necessary in order to increase habit and skill</i> Problem solving <i>Analyze, or prompt the person to analyze, factors influencing the behavior and generate or select strategies that include overcoming barriers and/or increasing facilitators</i>	Provide HD unit staff the opportunity to practice setting up bikes ahead of the intervention Encourage HD unit staff to anticipate and identify situational barriers that might interfere with setting up the bikes and develop backup plans to ensure they can set them up as intended
Need for exercise professionals	Social and professional role/environmental context and resources		Restructuring of the social environment <i>Change or advise to change the social environment in order to facilitate performance of the wanted or unwanted behavior</i>	Reconceptualizing the role typically filled by exercise professionals as one that can be shared among multiple unit staff (e.g. physicians, managers and bedside nurses) Determining what skills and training are feasible for unit staff to adopt and what aspects of IDE can only be fulfilled by an exercise specialist will be critical to planning for adequate resources Hire an exercise professional or provide staff access to expert advice (e.g. consultations with exercise
	Environmental context and resources		Social support (practical)	

Logistics of space, time and equipment	Environmental context and resources	<p><i>Advise on, arrange, or provide practical help (e.g. from friends, relatives, colleagues, buddies or staff) for performance of the behavior</i></p> <p>Restructuring of the physical environment</p> <p><i>Change or advise to change the physical environment in order to facilitate performance of the wanted or unwanted behavior</i></p> <p>Adding objects to the environment</p> <p><i>Add objects to the environment in order to facilitate performance of the behavior</i></p>	<p>professionals) to increase HD unit capacity to deliver an IDE program</p> <p>Arrange the HD unit to facilitate the efficient delivery of an IDE program (e.g. by creating space to store equipment, by grouping patients who engage in IDE, etc.)</p> <p>Working with local staff to identify and modify unit spaces and processes to address logistical concerns (e.g. grouping cyclists in low traffic areas)</p> <p>Provide HD units with the appropriate equipment to deliver an IDE program (e.g. bikes that fit dialysis chairs, bike mats, wedges, etc.)</p>
Social dynamics of the unit	Social influence	<p>Information about others' approval</p> <p><i>Provide information about what other people think about the behavior. The information clarifies whether others will like, approve or disapprove of what the person is doing or will do</i></p> <p>Social support (unspecified)</p> <p><i>Advise on, arrange or provide social support (e.g. from friends, relatives, colleagues, buddies or staff) or non-contingent praise or reward for performance of the behavior. It includes encouragement and counseling, but only when it is directed at the behavior</i></p>	<p>Communicating to staff and patients who support IDE (e.g. nephrologists, nurses, administration and patients) and why it may influence others to consider supporting/engaging in IDE</p> <p>Engage staff and patients in creating an environment where staff and patients are encouraged and praised by champions (and others) for participating in an IDE program</p>
Patient stories	Social influence	<p>Vicarious consequences</p> <p><i>Prompt observations (including rewards and punishments) of the consequences for others when they perform the behavior</i></p> <p>Social comparison</p> <p><i>Draw attention to others' performance to allow comparison with person's own performance</i></p> <p>Information about others' approval</p> <p><i>Provide information about what other people think about the behavior. The information clarifies whether others will like, approve or disapprove of what the person is doing or will do</i></p>	<p>Communicating the health benefits experienced by cyclists in the unit to other patients may help demonstrate the value of engaging in IDE</p> <p>Highlight the positive experiences of patients who have engaged in IDE</p> <p>Emphasize real-life examples of patients who are eligible, interested and engaged in IDE to encourage patients to reflect on their own willingness and ability to engage in IDE</p> <p>Tracking cyclists' progress in engaging ways (e.g. map representing distance cycled) may encourage others to maintain cycling practice</p> <p>Provide healthcare staff with evidence (e.g. patient stories) of patient approval regarding IDE processes and engagement</p>



patient perceptions of who is fit to exercise may therefore simultaneously address two long-standing barriers identified in the literature and in this study.

Our study focused on the accounts of healthcare providers and HD patients. Funders and policymakers are also an important stakeholder group to engage in future research given the human and resource constraints that are often cited as barriers. Other limitations of this study include overrepresentation of patients and staff from larger urban and academic hospitals, potentially limiting the transferability of our findings to smaller dialysis units located in rural settings. Additionally, while <10% of HD units in Ontario offered exercise programs or cardiac rehabilitation programs in 2012 [47], 44% ( $n = 19$ ) of participants had some experience with IDE programs. This likely represents a self-selection bias in that healthcare providers and

patients with prior IDE experience may have had a greater interest in this project. This may also account for the generally positive views that patient participants expressed in relation to IDE. Further research is needed to explicitly explore the views of patients who are not interested in IDE irrespective of past experience. Finally, our feasibility checklist and solutions were developed based on interviews conducted in one province and require further testing and validation in geographically and resource-diverse HD units.

The strengths of this study lie in the diversity of participant experiences with IDE (ranging from none to active current involvement in IDE) and the breadth of topics covered during interviews. To our knowledge, few studies have comprehensively assessed barriers and enablers across multiple HD sites, representing input from diverse stakeholder groups with

#### Equator network reporting checklist—COREQ checklist

Item	Guide questions/descriptions	Reported on page #
Domain 1: Research team and reflexivity		
Personal characteristics		
Interviewer/facilitator	Which author/s conducted the interview or focus group?	p. 6
Credentials	What were the researcher's credentials? (e.g. PhD, MD)	p. 6, title page
Occupation	What was their occupation at the time of the study?	p. 6
Gender	Was the researcher male or female?	p. 6
Experience and training	What experience or training did the researcher have?	p. 6
Relationship with participants		
Relationship established	Was a relationship established prior to study commencement?	p. 7
Participant knowledge of the interviewer	What did the participants know about the researcher? (e.g. personal goals, reasons for doing the research)	p. 7, <a href="#">Supplement 1</a>
Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? (e.g. bias, assumptions, reasons and interests in the research topic)	N/A, not reported. However, interviewer biases and assumptions were documented in a reflexivity journal.
Domain 2: Study design		
Theoretical framework		
Methodological orientation and theory	What methodological orientation was stated to underpin the study? (e.g. grounded theory, discourse analysis, ethnography, phenomenology and content analysis)	p. 6–7
Participant selection		
Sampling	How were participants selected? (e.g. purposive, convenience, consecutive and snowball)	p. 6
Method of approach	How were participants approached? (e.g. face-to-face, telephone, mail and e-mail)	p. 6
Sample size	How many participants were in the study?	p. 9
Nonparticipation	How many people refused to participate or dropped out? Reasons?	p. 9
Setting		
Setting of data collection	Where was the data collected? (e.g. home, clinic and workplace)	p. 7, 9–10, <a href="#">Table 2</a>
Presence of nonparticipants	Was anyone else present besides the participants and researchers?	p. 10
Description of sample	What are the important characteristics of the sample? (e.g. demographic data and date)	p. 9–10, <a href="#">Table 2</a>
Data collection		
Interview guide	<ul style="list-style-type: none"> <li>Were questions, prompts, guides provided by the authors? Was it pilot tested?</li> </ul>	p. 7, <a href="#">Supplement 1</a>

*Continued*

Continued

Item	Guide questions/descriptions	Reported on page #
Repeat interviews	Were repeat interviews carried out? If yes, how many?	p. 7
Audio/visual recording	Did the research use audio or visual recording to collect the data?	p. 7
Field notes	Were field notes made during and/or after the interview or focus group?	p. 7
Duration	What was the duration of the interviews or focus group?	p. 9–10
Data saturation	Was data saturation discussed?	p. 8
Transcripts returned	Were transcripts returned to participants for comment and/or correction?	p. 7
Domain 3: Analysis and findings		
Data analysis		
Number of data coders	How many data coders coded the data?	p. 8
Description of the coding tree	Did authors provide a description of the coding tree?	p. 7–8, 10, <a href="#">Table 3</a>
Derivation of themes	Were themes identified in advance or derived from the data?	p. 7–8
Software	What software, if applicable, was used to manage the data?	p. 7
Participant checking	Did participants provide feedback on the findings?	p. 7–8
Reporting		
Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? (e.g. participant number)	<a href="#">Table 3</a>
Data and findings consistent	Was there consistency between the data presented and the findings?	p. 10–14, <a href="#">Table 3</a>
Clarity of major themes	Were major themes clearly presented in the findings?	p. 10–14
Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	p. 10–14, <a href="#">Table 3</a>

shorter- and longer-term experience with exercise programs. In addition to identifying and confirming several factors that are key to address when considering IDE program delivery, we utilized a theoretical framework that allowed us to develop actionable solutions grounded in behavior change theory. Our feasibility assessment tool further facilitates identifying and addressing local barriers and improving the uptake of IDE in diverse settings.

Future research is needed to test the theoretical linkages between TDF-identified barriers and enablers, the mapped behavior change techniques and proposed operationalized solutions. Our delivery feasibility tool would likewise benefit from further testing and validation by comparing guiding questions to synthesized literature, conducting Delphi surveys with experts and assessing criterion validity by using our tool in conjunction with others (e.g. Nurses' Attitudes Toward Exercise in Dialysis tool [44]).

In conclusion, we identified potential evidence-based solutions to address barriers and optimize enablers that will facilitate IDE delivery in diverse units. We also developed a delivery feasibility tool for identifying and assessing which barriers may be relevant to address when designing multisite trials and considering clinical program delivery of intradialytic cycling.

## SUPPLEMENTARY DATA

[Supplementary data](#) are available at [ndt online](#).

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## AUTHORS' CONTRIBUTIONS

J.P., C.B., A.G. and G.C. were responsible for the research idea and study design. G.C., C.M., A.O.M., B.H. and M.T. were responsible for data collection. G.C., M.W., C.C., B.F., C.B. and J.P. were responsible for data analysis/interpretation. J.P. and C.B. were responsible for supervision and mentorship. G.C., C.B., J.P., S.T. and J.M. were responsible for manuscript drafting. All authors contributed substantive comments to earlier drafts and approved the submitted version.

## CONFLICT OF INTEREST STATEMENT

C.B. received research funding from Hope Pharmaceuticals and holds ownership interest in Precision Advanced Digital Manufacturing, outside the work reported in this article. The authors report no other conflicts of interest. The results presented in this article have not been published previously in whole or part, except in abstract format.

## DATA AVAILABILITY STATEMENT

The datasets generated and analyzed during this study will not be made publicly available in order to protect the privacy and confidentiality of study participants. However, de-identified, aggregated data have been made available in the article (see [Table 3](#)).

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