Take-home laparoscopic simulators to develop surgical skills: Analysing attitudes to, and barriers and enablers of, their use in gynaecology training

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Abstract

Introduction: Providing specialty trainees with take-home laparoscopic simulators may overcome known barriers to simulation-based surgical training such as limited time and access to equipment; however, programs utilising these simulators have reported suboptimal engagement from trainees. The purpose of this study was to understand factors influencing the use of take-home laparoscopic simulators and make suggestions to optimise engagement in future programs.

Methods: We interviewed 10 of the 16 gynaecology trainees who participated in a take-home laparoscopic box trainer simulation program. Interview transcripts were analysed and themes sorted using the Theoretical Domains Framework. Articulation of these domains with the Behaviour Change Wheel directed the formulation of targeted interventions.

Results: Trainees had positive attitudes towards simulation training; however, they experienced numerous under-recognised barriers to training. Trainees found their professional role, duties and competing life priorities limited time for training. Trainees experienced feelings of inertia and did not train as much as they anticipated. They were disengaged from training by a lack of real operating, a perceived poor relationship between training tasks and surgery and difficulties with equipment set-up. Self-directed practice, goal setting, task deadlines, perceived supervision, a recognition of personal skill development and an understanding of the need for simulation enabled training. Interventions were proposed to address the barriers to training.

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Conclusions: Trainee attitudes towards simulation and take-home trainers were positive, yet numerous barriers prevented them from training. Following a theory-driven process, we were able to devise targeted, evidence-based interventions, which may be incorporated into future versions of the program.

Keywords: curriculum; education, medical; gynaecology; laparoscopy; simulation training; Theoretical Domains Framework.

Introduction

Surgical specialty training programs face the challenge of ensuring clinical competency amongst their trainees in a climate of increased trainee numbers, reduced working hours and limited access to surgical opportunities for training (Bisson, 2018). Such factors have led to a concern that new gynaecology fellows do not have the confidence and skills to perform at the necessary level across the procedures required for the discipline (Driessen, Janse, Schreuder, & Jansen, 2015; Guntupalli et al., 2015; Obermair, Tang, Charters, Weaver, & Hammond, 2009). Simulation provides a means for trainees to develop surgical skills in a controlled environment and can serve as an adjunct to existing surgical training methods (Motola, Devine, Chung, Sullivan, & Issenberg, 2013).

There is an ever-increasing body of research to demonstrate that simulation can be used to improve surgical skills and operative performance, particularly in laparoscopic surgery (Munro, 2012). Simulation provides opportunities for deliberate practice and mastery learning without endangering patients and assists the development of the technical skills required in laparoscopy (Motola et al., 2013). It has been suggested that evidence for the use of simulation is so strong that there is an ethical imperative for such training to be utilised (Ziv, Wolpe, Small, & Glick, 2003). There is, however, doubt that the uptake of simulation is keeping pace with the evidence to support its use (Aggarwal & Darzi, 2011; Stefanidis et al., 2015). Simulation appears to be sparsely incorporated into gynaecology training in Australia (Wilson, Janssens, Hewett, Jolly, & Beckmann, 2016). Commonly reported barriers to the uptake of simulation training include cost, access to simulation equipment, supervision and time (Korndorffer et al., 2013; Savoldelli, Naik, Hamstra, & Morgan, 2005; Shetty, Zevin, Grantcharov, Roberts, & Duffy, 2014; Stefanidis et al., 2015; Wilson et al., 2016).

The use of take-home box trainers has been suggested as a strategy to overcome barriers to equipment access and time for training (Thinggaard et al., 2016). The majority of identified studies were performed in the United States (US) (Arden, Hacker, Jones, & Awtrey, 2008; Caban et al., 2013; Kobayashi et al., 2011; Korndorffer, Bellows, Tekian, Harris, & Downing, 2012; Zapf & Ujiki, 2015) in a training environment where laparoscopic simulator assessment is a mandatory part of surgical credentialing (Brown & Paige, 2015). Some studies evaluated take-home trainers as a feature of established simulation programs (Chummun, Burke, O'Sullivan, & Prendiville, 2012; Korndorffer et al., 2012; Thinggaard, 2017; Zapf & Ujiki, 2015), making it difficult to isolate the role of the take-home component of training. Trainee practice was seldom reported, though when recorded practice was considered reasonable, it was often attributed to

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mandatory components of a wider simulation program (Arden et al., 2008; Korndorffer et al., 2012; Zapf & Ujiki, 2015). Other studies found participants lacked motivation to practise (Furnee et al., 2009; Nicol, Walker, Cleland, Partridge, & Moug, 2016) or reported low levels of simulator use (Nicol et al., 2016; Russo & Tsuda, 2011; Stovall, Redick, & Prettyman, 2010). Few of the studies examined barriers and enablers to training. Those that did found low motivation, limited time, unclear training goals, lack of feedback and difficulties with technical aspects of simulators (camera views, instruments, software, set-up space) were impediments to training (Nicol et al., 2016; Thinggaard, 2017; van Empel et al., 2012; Zapf & Ujiki, 2015). On-site training and feedback were motivators (Thinggaard, 2017; Zapf & Ujiki, 2015).

Implementing new practices, such as simulation training, requires a change in behaviour of the involved personnel (Atkins et al., 2017). The field of implementation science (IS) acknowledges that simply producing and disseminating guidelines and protocols or delivering training sessions does not always affect practice change (Eccles & Mittman, 2006). To facilitate appropriate and sustained change, methods of identifying specific barriers and enablers to the desired behaviours and then design and delivery of appropriate, effective interventions are required (Michie, van Stralen, & West, 2011). Methodologies within IS promote rigorous approaches to systematically assess barriers and enablers to health professionals, teams and organisations and to select appropriate interventions to overcome the barriers identified. Thus, a theory-driven approach is crucial to understanding why implementations succeed and fail in the healthcare environment as well as to address identified barriers to adherence to best practice (Damschroder et al., 2009).

An integrative framework, the Theoretical Domains Framework (TDF) (Figure 1) (Francis, O'Connor, & Curran, 2012), has been designed as a vehicle to help apply theoretical approaches to interventions aimed at behaviour change and provide an explicit framework for evaluation. The TDF aims to synthesise a multitude of coherent behaviour change theories into a single framework that allows assessment and explanation of behavioural problems and associated barriers and enablers, and inform the design of appropriately targeted interventions. The TDF, consisting of 14 "domains", was developed through an expert consensus process, including factor analysis and validation to identify psychological and organisational theories relevant to health practitioner clinical behaviour change (Francis et al., 2012). The 14 domains are: knowledge; skills; behavioural regulation; emotion; social influences; environmental context and resources; memory, attention and decision processes; goals; intentions; reinforcement; beliefs about consequences; optimism; beliefs about capabilities; social/professional role and identity. Identification of project-specific domains can be explored (prospectively) through interviews, questionnaires and observation, or it can be used as a coding framework (retrospectively) for analysis of data (barriers) collated from numerous sources (Francis et al., 2012). Constructs exist in each domain to enable identification, classification and refinement of these behaviour change barriers into appropriate domains at individual, team, and organisational levels. Following identification of project-relevant domains, application of evidence-based behaviour

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change interventions that work at individual, team or organisational level can be applied (e.g., using the Behaviour Change Wheel (BCW)) (Colquhoun et al., 2014; Michie et al., 2011; Straus, Tetroe, Graham, & Graham, 2009).

TDF Domain	Definition
Knowledge	An awareness of the existence of something
Skills	An ability or proficiency acquired through practice
Memory, attention and decision processes	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives
Behavioural regulation	Anything aimed at managing or changing objectively observed or measured actions
Social influences	Those interpersonal processes that can cause an individual to change their thoughts, feelings or behaviours
Social/professional role & identity	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting
Beliefs about consequences	Acceptance of the truth, reality or validity of outcomes of a behaviour in a given situation
Beliefs about capabilities	Acceptance of the truth, reality or validity of an ability, talent or facility that a person can put to constructive use
Optimism	The confidence that things will happen for the best or that desired goals will be attained
Intentions	A conscious decision to perform a behaviour or resolve to act in a certain way
Goals	Mental representation of outcomes or end states that an individual wants to achieve
Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus
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 behaviour
Emotion	A complex reaction pattern involving experiential, behavioural and physiological elements, by which the individual attempts to deal with a personally significant matter or event

Figure 1. *Theoretical Domains Framework domains* (Cane, O'Connor, & Michie, 2012).

When a program using take-home laparoscopic simulators was implemented in 2016, the use of the simulators and engagement with program tasks was lower than anticipated (Wilson et al., 2018). Therefore, we planned a study of the trainees who participated in the take-home simulation program, using a theory-based approach to understand factors influencing the use of this method of simulation training. This study aims to use the TDF to perform a systematic assessment of barriers and enablers, and make recommendations for future programs (Atkins et al., 2017).

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Materials and methods

Design and setting

A qualitative descriptive study was performed using semi-structured interviews of the trainees who participated in a surgical training program using take-home laparoscopic simulators in 2016 (for a copy of the interview guide, please contact author). This represented the total cohort of trainees in gynaecology at the hospital that year. The study was undertaken at a tertiary hospital in Brisbane, Australia, which is a major training site for gynaecology trainees in the state. The study was approved by the Mater (HREC/14/MHS/194) and University of Queensland (2015001608) ethics committees.

The training program

Prior to this study, participants were involved in a simulation program utilising portable trainers, enabling use at home. Trainees in gynaecology were issued a take-home box trainer, associated instruments and software. The program provided a supportive curriculum of eight tasks and performance targets. Trainees were advised to train on one task each month and received email reminders. Half the trainees were allocated additional supervision during the initial program to assess the role of supervision on training outcomes. All trainees received email updates and reminders of the monthly task. Participants were given a logbook to record their practice times. They also were required to perform box trainer and virtual reality simulator tasks at the beginning and end of the training to evaluate performance and skill development. Unfortunately, many participants failed to complete logbooks (6/16) or performance tasks (7/16), which suggested suboptimal engagement with the training program (Wilson et al., 2018).

Authors EW and SJ were involved in sending reminder emails and coordinating the initial program and distribution of the resources to participants.

Participants

All original trainees (n = 16) in the simulation program in 2016 were invited by email to participate. Participants included trainees from all levels of the 6-year gynaecology training program as well as junior unaccredited specialist trainees. Participants provided consent for a recorded phone interview. Participants were interviewed until data saturation was reached. The participants from the program who did not respond to the email invitation were not further pursued when saturation of data was noted on analysis.

Data collection and analysis

The principal researcher (EW) conducted the interviews, and the audio recordings were de-identified and transcribed for analysis. EW was a gynaecology trainee no longer working at the hospital but known to some participants. Two researchers (EW and BJ) reviewed the transcripts and independently coded two interviews before discussing and agreeing on a coding framework. Each researcher then coded the remaining transcripts,

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noting illustrative segments of text. EW and SW then classified, sorted and synthesised the codes, in consultation with BJ, and shared with the other investigators through a process of iterative categorisation. Final themes and subthemes were agreed by discussion and consensus.

Application of the TDF

Authors EW and SW sorted the identified barriers and enablers into the domains of the TDF in an iterative, consensus process (Colquhoun et al., 2014; Francis et al., 2012; Michie et al., 2011). Constructs within each of the domains of the TDF were used to assist with identification, classification and refinement of these issues into appropriate domains. Following the process outlined in Michie et al. (2011), the "capability–opportunity–motivation–behaviour" (COM-B) BCW (Michie et al., 2011) was used to identify key strategies required to effectively address and overcome the barriers identified through behaviour change techniques—with additional input from emerging literature that combines the BCW, the Cochrane effective practice and organisation of care (EPOC) website, the Leeman taxonomy and behaviour change techniques (Table 1) (Colquhoun et al., 2014). A number of evidence-based strategies were subsequently proposed for incorporation into future programs, with the aim to improve trainee engagement.

Results

We interviewed 10 trainees who completed the simulation program in 2016. Interviews were 10 to 21 minutes in duration. Participants included two unaccredited trainees, six trainees in years 1–4 of the training program and two advanced trainees. There were more female (7/10) than male (3/10) participants. Detailed analysis of the transcripts revealed four major themes. These were participant expectations about simulation and the outcomes of training, program content, integration and motivations.

Participant expectations about simulation and the outcomes of training

Trainees revealed an understanding of the role of simulation and believed in the capacity for simulation to improve their procedural skills. They expressed a desire for skill improvement and acknowledged that the program enabled a progression through levels of difficulty. They recognised their own skill development through the course of the training and believed that this translated into improving their operative performance. Interestingly, both junior and senior trainees commented that the training was suitable to their level of training, noting differing training benefits. For example, junior trainees reported it was helpful to establish basic skills prior to patient contact, while senior trainees found it was valuable to consolidate their skills and provided the opportunity for deliberate practice in areas of identified deficiency (such as suturing).

> *I think there's lots of evidence ... [that] those that have had simulation training prior to hands-on operating have a much better skills acquisition and are much better from a safety point of view. I just think that especially in a setting where operative exposure and experience is getting less and less, I think it's an invaluable opportunity for trainees.* (P3)

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Table 1
TDF Domains Relevant to Barriers for Gynaecology Trainees Paired With Evidence-Based Interventions Informed by BCW/COM-B1 and Interventions From Colquhoun et al. (2014) With Operational Examples

TDF Domain	Aligned Identified Barriers	Aligned Identified Enablers	Potential Appropriate Intervention Styles [a]	Examples of Operationalisation of Interventions (detailed in Table 2)
Skills		Recognised their own skill development	Training Modelling Restrictions	• Supervisor allocated to each trainee can provide feedback on skill development (modelling) – Use of an opinion leader
Behavioural regulation	Disconnect between intention to train and reality		Enablement Modelling Enablement	• Supervisor allocated to each trainee (modelling) – Use of local opinion leader • Introductory education session (enablement) – Goal setting – Problem solving – Comparative imagining • Trainee contract (enablement) – Behavioural contract – Action planning • Set and self-chosen tasks of graded difficulty (enablement) – Goal setting – Graded tasks
Social/professional role & identity	Professional role as a busy doctor	Want supervision	Environmental restructure Education	• Supervisor allocated to each trainee (education) – Information about others' approval – Feedback on behaviour • Complementary in-hours training (environmental restructure) – Exposure – Changing the social environment
Beliefs about consequences		Belief that simulation improved operative skills and this translated to operative environment	Environmental restructure Education	• Trainee-centred curriculum coupled with supervisor allocated to each trainee (education) – Feedback on the behaviour and/or outcome(s) of the behaviour – Self-monitoring of behaviour and/or outcomes of behaviour – Information about social and environmental consequences – Information about others' approval

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TDF Domain	Aligned Identified Barriers	Aligned Identified Enablers	Potential Appropriate Intervention Styles [a]	Examples of Operationalisation of Interventions (detailed in Table 2)
Beliefs about capabilities		Recognition of need for simulation related to their level of experience Self-directed training Independent practice at own pace without fear of judgement	Environmental restructure Education	• Trainee-centred curriculum (education) – Self-monitoring of behaviour and/or outcomes of behaviour
Optimism	Perceived poor relationship between designated tasks and operative skills		Environmental restructure Education	• Providing information about benefits of simulation in introductory session (education) – Re-attribution – Information about consequences • Trainee-centred curriculum coupled with supervisor allocated to each trainee (education) – Feedback on the behaviour and/or outcome(s) of the behaviour – Self-monitoring of behaviour and/or outcomes of behaviour – Information about social and environmental consequences
Goals	Lack of real operating	Upcoming operating Goal setting and desire to improve performance	Environmental restructure Education	• Providing information about benefits of simulation in introductory session (education) – Re-attribution – Information about consequences • Complementary in-hours training (environmental restructure) – Exposure – Changing the social environment
Reinforcement		Program tasks and deadlines Belief that training should be mandatory	Enablement Coercion Education	• Trainee contract (coercion and enablement) – Commitment (coercion) – Action planning (enablement) • Set and self-chosen tasks of graded difficulty (enablement) – Goal setting – Graded tasks

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TDF Domain	Aligned Identified Barriers	Aligned Identified Enablers	Potential Appropriate Intervention Styles [a]	Examples of Operationalisation of Interventions (detailed in Table 2)
Environmental context and resources	Hardware components (such as instruments) different to those used in real surgery Limited space at home to leave box trainer set up Perceived low value of logbook Lack of in-hours protected time for training Competing priorities: work and life	Access to equipment (given to trainee and could use at home)	Incentivisation Persuasion Environmental restructure	• Supervisor allocated to each trainee to provide feedback on the behaviour (persuasion) • Complementary in-hours training (environmental restructure) • Frequency based practice logbook (environmental restructure) • Behavioural reinforcement activities (incentivisation) • Flexible task timetable (environmental restructure) • Home restructuring advice in introductory session (environmental restructure)
Emotion	Feelings of inertia		Enablement Coercion Education	• Trainee contract (coercion) o Self-monitoring of behaviour o Commitment o Behavioural contract • Supervisor allocated to each trainee (coercion) o Monitoring of behaviour by others • Introductory education session (education) o Information about consequences o Information about others' approval • Social support provided through introductory session, in-hours training and supervision (enablement)

1 Michie et al., 2011

a Training—imparting skills; Modelling—provide an example for people to aspire to or imitate; Restrictions—using rules to reduce opportunity to engage in the target behaviour (or increase the target behaviour by reducing the opportunity to engage in competing behaviours); Enablement—increasing means/reducing barriers to increase capability or opportunity; Environmental restructure—changing the physical or social context; Education—increasing knowledge or understanding; Coercion—creating expectation of punishment or cost; Incentivisation—creating expectation of reward; Persuasion—using communication to induce positive or negative feelings or stimulate action

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> *Instrument handling, learning to use two hands, passing from one hand to another, orientating yourself and just that hand–eye coordination.* (P8)

> *I think it did overall improve my dexterity and my ability to perform laparoscopic tasks. I think it did give me a good foundation, to starting to do my own procedures under the supervision of consultants.* (P10)

All trainees reported that despite a desire to train, there was a disconnect between their intentions and reality, where they practised less than they had imagined. There was a collective suboptimal engagement.

> *I guess the other major reflection I have is that I didn't use my box trainer as much as I would have wanted to or predicted that I would have.* (P5)

Program content

The theme of program content included both training access and curriculum features. Trainees reflected on the value of being given access to simulation equipment and the capacity to train at home. Most participants felt the equipment was easy to set up at home, but some commented that hardware components were different to that used in theatre (such as the needle holders). Limited space at home to leave the equipment open and ready for use prevented more frequent practice. Trainees enjoyed being able to work at their own pace in an environment where they could perform skills without fear of judgment from their supervisors.

> *I like the ease of having it at home and, like I said, being able to fumble through it and feel a bit uncoordinated without somebody standing over your shoulder.* (P8)

> *If I was able to sort of leave it set up … in a place that I walk past … I might just play with that for a bit. But I just didn't have that much room … just having to remember to pull it out and open it all up.* (P6)

The tasks in the curriculum were seen to enable skill acquisition, and trainees identified how they could promote the development of necessary operative skills. However, some trainees felt it was difficult to see how some of the tasks related to real surgery, and it was suggested that an explanation of how a simulated task improves an aspect of surgical technique could improve engagement.

> *If you've got [four dice] and you want them stacked in your abdomen, I can do that [laughs]. I know it's useful for hand–eye coordination, but it does sort of seem there's no real correlation [with] what we do surgically.* (P7)

Participants admitted to haphazard recording of practice times in the logbook provided. They often felt their use of the trainer was too short or interrupted to warrant recording. This finding questions the validity of the logbook data reviewed in the original study.

> *The logbook was [a helpful] thing to do … [however] there were times that I'd do training and I wouldn't log it because it was literally 2 minutes.* (P3)

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Program integration

Trainees felt they would have trained more if they had been allocated in-hours time for simulation. An integrated approach was suggested where the at-home training could be complemented by in-hospital practice sessions with supervision and teaching. They felt this would provide additional motivation to then practise at home.

> *I think people are probably more likely to complete the exercises and maybe be more receptive to it if you give them time in hours for it.* (P2)

> *The lap sim sessions [part of routine surgical training at the hospital]… I'd get actually a bit of guided teaching. That would motivate me to come home and do a little bit on the box trainer as well.* (P3)

There was divided opinion on whether the simulation program, or similar future programs, should be mandatory for trainees. Some recognised that forced participation or sanctions would drive increased participation and subsequent benefit for trainees. Others expressed reluctance for mandatory participation, feeling it would detract from the enjoyment of the program.

> *Sometimes you have to force people to do things … trainees should have something like this built into their curriculum.* (P2)

> *You'd take the fun aspect out of it by making it mandatory … I would actively discourage you from making it mandatory.* (P1)

In discussing mandatory training, it emerged that some participants felt the onus was on the training hospital to provide the equipment, time and supervision for practice, whilst others felt that trainees, ultimately, are responsible for their own participation in skill development programs.

> *At the end of the day, we're adults. You shouldn't have to make someone chase you, and in real life … no one's going to chase you to do things.* (P6)

Motivations

The strongest overall influence on the motivation to train appeared to be the trainee's assessment of their free time to practise. Trainees revealed numerous competing priorities for their time, including shift work, work-associated duties (such as research, guideline development) and parenting.

> *I just think with all the hours spent at work and then doing other things related to work, like research projects and policies et cetera, there was just no time left to do the box training project as well.* (P4)

> *I had some family changes during the program. I had a baby and obviously that becomes a bit more distracting and less time.* (P5)

Some trainees felt even when they had the time, they experienced inertia to get started.

> *It's just that when I had free time, I would rather spend it doing exercise, or watching TV, or doing something to chill out [laughs].* (P6)

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Participants appeared to identify their role as a doctor as a busy one and associated this with a difficulty in taking on additional duties.

> *The crux of it is when you're a busy O&G registrar [gynaecology specialty trainee], there are so many demands on your time.* (P5)

Participants felt that having task-related goals and competing with their own prior performance motivated them to practise. They also felt the implied deadlines of the program (monthly tasks allocation) prompted ongoing participation. Those who were assigned to additional supervision revealed that they found this motivating due to the desire to impress a senior clinician they respected.

> *I wanted to get better … it was fun trying to get better than last time.* (P1)

> *Someone looked at your video, so you knew one of the consultants who I respected was going to look at my video and I didn't want them to think badly of me. So I think that's motivating.* (P7)

Trainees also felt that their exposure to real operating impacted on their motivation to practise with simulation. Whilst some trainees felt this was a motivator and used simulation to practise skills prior to operating, others felt a lack of real-life operating reduced their motivation to engage with the program.

> *My primary motivation was that I would … try and do some the night before my list and that sort of thing.* (P9)

> *It's hard because you get so little operating [during work] to then put it into practice.* (P8)

Categorisation of identified barriers and enablers into the TDF

The barriers and enablers identified in the thematic analysis above were subsequently sorted according to the domains of the TDF (Figure 1). Table 1 demonstrates the relationships between the TDF domains, the identified barriers and enablers, evidence-based intervention styles and planned interventions. The process of sorting the barriers and enablers into the domains of the TDF guided the selection of appropriate intervention styles from the literature. This allowed the generation of theoretically-grounded strategies to overcome the recognised barriers according to the related behaviour change techniques (Table 2).

Discussion

Our findings indicate that trainees participating in a take-home box trainer simulation program value simulation and perceive training to be useful to their skill development and operative performance. Both junior and senior trainees enjoyed self-directed practice in their own environment without fear of judgement. Trainees' desire to use the simulators, however, was in conflict with numerous barriers to training. Trainees reported feelings of inertia and competition for their "free" time, leading to an overall disconnect between intention to practise and reality. Goal setting, supervision and real "live" operating were motivators for training. Trainees were divided as to whether

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Table 2
Curriculum Structure and Strategies for Take-Home Simulator to Operationalise the Interventions Outlined in Table 1

Intervention	Description
1. Supervisor allocated to each trainee	• Each trainee allocated a supervisor for the duration of the program • Supervisors given exemplars of feedback provision • Trainees informed to correspond with supervisor (online uploads of videos, email feedback) for each task
2. Introductory education session	• Explain program curriculum • Provide supportive evidence and rationale for simulation training • Demonstrate set up and use of equipment • Inform trainees of contacts for troubleshooting • Encourage comparative imaging
3. Trainee contract	• Trainees to set personal goals for task skill attainment (levels of difficulty 1, 2 or 3) • Make a personal contract outlining anticipated achievable training frequency and submissions for feedback
4. Set and self-chosen tasks (trainee-centred curriculum)	• Curriculum of 10 tasks from which trainees choose tasks for a self-directed curriculum • Trainees have a monthly focus task to request feedback on from their supervisor and attain achievement level • Trainees encouraged to also practise tasks from their curriculum as desired throughout program to meet learning goals. For example, participants may prefer to spend more time on suturing tasks and practise this around the "focus task" of the month.
5. Flexible task timetable	• Trainees make a personal schedule of training for each task in curriculum over a maximum 12-month period • Allow trainees to have a "month off" when on a busy rotation, night shifts or annual leave, as required
6. Complementary in-hours practice	• Dedicated simulation sessions allocated in education timetable. Senior clinician(s) present to provide in-person supervision and feedback • Have simulator available in operating theatre sessions for supervised practice between operative cases
7. Home environment restructuring advice	• Trainees to brainstorm options for setting up equipment at home to facilitate access and frequent practice • Trainees given examples of setups from previous successful users of simulators. For example, trainees found having simulator permanently set up on study desk enabled frequent use.
8. Frequency-based practice logbook	• Logbook updated to include a log of practice frequency as well as duration • Revise format to increase compatibility with personal electronic devices
9. Behavioural reinforcement activities	• Supervisors to post trainee achievements on department communication application • Certificates of completion provided to trainees with each goal level attained

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such training should be mandatory and, ultimately, differed in their opinion of where responsibility lies for the development of their surgical skills.

Strategies for improving engagement with training

Clinicians often make assumptions about what the barriers to implementation are and proceed with strategies based on this assessment (Page, Gilroy, Hurrion, Clark, & Wilkinson, 2017). Behaviour change interventions grounded in theory are more effective than those based on intuition (Albarracín et al., 2005; Chang & Crowe, 2011). Due to the difficulty in applying numerous, often overlapping, motivational theories, the TDF synthesises theories and constructs through the consensus of experts to allow the selection of effective behaviour change techniques (Michie et al., 2005). The theory of planned behaviour (Ajzen, 1991), social cognitive theory (Bandura, 1986), theory of reasoned action (Ajzen & Madden, 1986) or models of organisational cultural change (Scott, Mannion, Davies, & Marshall, 2003) could be applied to such research (Lipworth, Taylor, & Braithwaite, 2013). Each alone was considered unsuitable to gather the broad potential influences on behaviour in the research setting. However, the social cognitive theory highlights self-efficacy, response behaviour and environmental influences as key to motivation, and such concepts were seen within our analysis (Bandura, 2001). These constructs are captured as core features of the TDF domains. From the detailed analysis performed in this study and subsequent application of the TDF and BCW (Table 1), we have identified behaviour change techniques and suggested intervention strategies (Table 2) for future iterations of this program.

Ideally, a future program should begin with a face-to-face introductory session to provide the evidence for simulation training and a rationale for the curriculum. This strategy would provide the opportunity to inform trainees of the benefits of deliberate practice, distributed practice and mastery learning (Issenberg, McGaghie, Petrusa, Lee Gordon, & Scalese, 2005). Simulation, through these principles, can assist skill development despite limited access to real operating, a barrier categorised to the "goals" domain that aligns with education as an appropriate intervention style (Michie et al., 2011). An introductory session should also guide goal setting, problem solving and comparative imaging. These enablement interventions align with the TDF domain of behavioural regulation and target the identified barrier of trainee feelings of inertia (Table 1). Recognising the barriers of shift work and the busy role of doctors, a flexible task timetable would schedule training closer to surgical opportunities and could improve engagement (Colquhoun et al., 2014). Trainees in our program who received additional supervision felt motivated by a desire to impress the senior clinician. All trainees should be allocated a supervisor in future programs to provide the feedback and behavioural monitoring that could overcome feelings of inertia and encourage practice (Colquhoun et al., 2014).

Logbooks may incentivise practice (Korndorffer et al., 2012; van Empel et al., 2012), but our study revealed trainees often did not log time due to a perception that the amount of time spent training was not worth recording. Similarly, Bennett, Carter, Fory, Rodd and Longman (2016) reported poor compliance with logbooks. Changing

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to a frequency-based practice logbook via environmental restructuring may improve adherence and promote training (Table 1). Further stimuli to practise include a trainee-centred curriculum of self-directed tasks with a range of difficulty (Issenberg et al., 2005). Additional incentives proposed are the behavioural reinforcements of rewards for achievement (Colquhoun et al., 2014; Michie et al., 2011) and goal setting (Issenberg et al., 2005; Thinggaard et al., 2016). Personal trainee contracts (aligning with the intervention styles of enablement and coercion) may promote training, as people desire to be consistent with commitments (Cialdini, 1993).

Mandatory training

Some trainees in our study argued strongly against making training mandatory and believed the onus was on training institutions to provide the time and resources to train. Other participants felt that trainees may benefit from enforced participation in this sort of additional training. Potentially, there is a need to make simulation training mandatory. Previous studies have found suboptimal participation in voluntary training, and mandatory training has been suggested (Chang, Petros, Hess, Rotondi, & Babineau, 2007; van Dongen, van der Wal, Rinkes, Schijven, & Broeders, 2008; Zapf & Ujiki, 2015). However, other studies have reported trainees are reluctant for simulation training to be mandatory (Burden, Fox, Hinshaw, Draycott, & James, 2016; Korndorffer et al., 2013; Wilson et al., 2016). Making simulation mandatory could detract from the trainee-centred nature of a curriculum and may forego an opportunity to optimise the delivery of simulation. Integrated systems of simulation-based education appear to promote "voluntary" engagement, as seen from studies in the US (Caban et al., 2013; Kobayashi et al., 2011; Korndorffer et al., 2012) and those where take-home training was apparently implemented in conjunction with established simulation programs (Thinggaard et al., 2017; Zapf & Ujiki, 2015). Participants in our study expressed a desire for in-hours protected time for simulation training. Future programs would likely benefit from complementing in-hours protected opportunities to develop skills with supervision and feedback (Issenberg et al., 2005). As the role of simulation-based training becomes more integrated in local training systems, there may be a reduced requirement for this additional assistance.

Study strengths and limitations

The strengths of this study include the detailed information provided by participants that was specific and reflective of their individual experience. The single interviewer provided consistency for gathering of this information. Using a theoretical framework to arrange findings enhances understanding in the healthcare context and the potential for wider application of the results. Study limitations include the potential for participation bias, where voluntary participation may have encouraged only trainees with certain positive or negative feelings to participate. Also, the interviewer was known to some of the trainees, which may have influenced openness. However, the indirect relationship with participants was unlikely to have prevented honest disclosure, as reflected in the range of responses elicited in the interviews. The number of participants was small,

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though represented a majority of the original participants. The supervisors were not interviewed in this research but could have presented alternative insights into factors impacting the success of this program.

Future directions

Our take-home laparoscopic program intended to increase engagement in simulation by giving trainees access to a simulator, out-of-hours opportunity for practice, a curriculum of graded difficulty of tasks and set goals for attainment. Despite this, trainees reported numerous factors impacting their motivation to train. There is a need to consider curricula design and how best to balance the benefits of independent self-directed out-of-hours training with supervised, protected, in-hours practice sessions. Trainees appear to desire these in-hours sessions, and they may provide opportunities for interaction and mentoring. Unfortunately, in-hours-training in simulation competes with clinical responsibilities and restricts non-simulation training opportunities such as direct patient contact. Whilst making simulation training mandatory has been suggested in the literature (Thinggaard et al., 2016; Thinggaard et al., 2017; Zapf & Ujiki, 2015), this is not desired by all trainees and may be unreasonable in an environment without integrated simulation programs or a culture of simulation-based credentialing. There is a need for training institutions (colleges and training hospitals) to find the balance between service provision and surgical training.

Conclusion

Trainees revealed a range of barriers to explain suboptimal participation in a take-home simulator program. Barriers in line with existing literature include a lack of free time and difficulties with equipment or set up. We recognised additional barriers—a lack of real operating, feelings of inertia, underutilisation of logbooks, restrictions related to the "busy doctor" role and a variety of competing life priorities. Fortunately, trainees retain positive attitudes towards simulation and believe in the value of this training for their skill development, regardless of seniority. The use of a theory-driven process enabled the development of targeted, evidence-based interventions that align with recognised behaviour change techniques. Research on future programs would be essential to evaluate the success of such strategies.

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