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Playing Active Video Games may not develop movement skills: An intervention trial

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ABSTRACT

Background: To investigate the impact of playing sports Active Video Games on children's actual and perceived object control skills. *Methods*: Intervention children played Active Video Games for 6 weeks (1 h/week) in 2012. The Test of Gross Motor Development-2 assessed object control skill. The Pictorial Scale of Perceived Movement Skill Competence assessed perceived object control skill. Repeated measurements of object control and perceived object control were analysed for the whole sample, using linear mixed models, which included fixed effects for group (intervention or control) and time (pre and post) and their interaction. The first model adjusted for sex only and the second model also adjusted for age, and prior ball sports experience (yes/no). Seven mixed-gender focus discussions were conducted with intervention children after programme completion. *Results*: Ninety-five Australian children (55% girls; 43% intervention group) aged 4 to 8 years (M 6.2, SD 0.95) participated. Object control skill improved over time ($p = 0.006$) but there was no significant difference ($p = 0.913$) between groups in improvement (predicted means: control 31.80 to 33.53, SED = 0.748; intervention 30.33 to 31.83, SED = 0.835). A similar result held for the second model. Similarly the intervention did not change perceived object control in Model 1 (predicted means: control: 19.08 to 18.68, SED = 0.362; intervention 18.67 to 18.88, SED = 0.406) or Model 2. Children found the intervention enjoyable, but most did not perceive direct equivalence between Active Video Games and 'real life' activities. *Conclusions*: Whilst Active Video Game play may help introduce children to sport, this amount of time playing is unlikely to build skill.

Introduction

In a study of nearly 13,000 UK children, only a small proportion met physical activity guidelines and this was coupled with a large part of the day in sedentary behaviour (Griffiths et al., 2012). In 2011–2012, only one in five Australian children met both the physical activity (>1 h per day) and screen recommendations (<2 h per day) (Australian Bureau of Statistics, 2013). Given the global burden of disease attributed to the lack of physical activity and sedentary behaviour, there is an urgent need to generate a strong evidence base around ways to mitigate the burden (Kohl et al., 2012), particularly ways that could be easily integrated into children's daily life/homes. One such potential strategy includes Active Video Games (AVGs).

Some sport-based AVGs require movements that replicate sports skills (such as striking and rolling a ball) (Papastergiou, 2009), therefore AVGs may help develop children's fundamental movement skills (FMS) (Barnett et al., 2013a). At least 50% of children do not master basic FMS such as catching, throwing and jumping; even by mid high school (Barnett et al., 2013b; Hardy et al., 2013). Without these 'building blocks' children are at risk of being less physically active (Lubans et al., 2010), as a child who is 'object control' (OC) competent (e.g. possessing ball handling skills) is more likely to be active (Barnett et al., 2009), and fit (Barnett et al., 2008; Vlahov et al., 2014) in adolescence.

The use of AVGs has been examined using Self-Determination Theory (Straker et al., 2014). Self-Determination Theory suggests that intrinsically motivated behaviours are performed for their inherent enjoyment, rather than to gain a reward, and that this sort of motivation is more apparent when there is choice, a perspective of competence and the ability to engage with others (Deci and Ryan, 2008). Thus, children's perceived competence may also increase with AVG play because the more-easily mastered 'virtual' sports and games may give children an optimistic bias in their potential for successfully engaging in these activities (Barnett et al., 2014b).

Whilst an observational study found that AVG use was associated with higher OC ability in pre-school aged children (Barnett et al., 2012), no research to date has investigated whether 'playing' sports AVGs can increase children's perceived and actual OC skills. This is an important research question as these games are typically used by children in the context of *free* play, and if playing these games elicit

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movement skill benefit then this has important health implications. If AVG play benefits children's skills, then we can recommend to parents, teachers and sporting organisations that AVG play may help to: i) introduce children to a particular activity or sport, ii) motivate children to engage in sport and/or physical activity, or iii) supplement sports participation. This pilot study investigated whether participation in an AVG play-based sports programme increased children's actual OC and perceived (POC) skills. It was hypothesised that both actual and perceived skills would improve by playing AVGs. In addition, children's perceptions of the acceptability of this approach were assessed post-intervention using qualitative data.

Methods

Background parent information

At the time of consent, the responding parent was asked to provide: their country of birth, language spoken most at home, highest level of education, and employment status.

Intervention procedure

Intervention children were asked to attend a one hour after school Nintendo Wii® session per week for six weeks. Two consoles were provided, with four children allocated to each timeslot; therefore, children played in pairs. Two research assistants supervised each session but were instructed not to provide skill coaching, although they could provide help on how to play the game i.e. scroll through the menu. The Nintendo Wii® games were specifically chosen to represent a range of sports which require the use of OC skills. A different set of games was offered each fortnight and children were allowed to choose. During each session, and for each child, research assistants recorded the time spent in: each game, administration (e.g. completing roll call), and time off task e.g. bathroom breaks.

Outcome measures

The Test of Gross Motor Development-2nd Edition (TGMD-2) assessed OC competence (striking a stationary ball, stationary dribble, kicking, catching, overhand throwing, and underhand rolling) according to established protocols (Ulrich, 2000). Each attempt was scored with each component of the skill receiving a ‘1’ if correctly executed or a ‘0’ if not. Scores of the two trials were summed to obtain a raw score for each skill and then the six skill scores for each child were summed to provide an OC score. All children were assessed in the school setting using live observation by two trained observers (12 h conducted by an expert trainer). In the field, inter-rater reliability was assessed on 37 children for all six skills; equating to 222 skill tests with excellent results ($ICC = 0.93$, 95% CI 0.87–0.96) (Barnett et al., 2014a).

A valid and reliable pictorial instrument based on the six OC skills in the TGMD-2 was used to assess POC competence (Barnett et al., 2015b). Boys received the booklet depicting boy cartoon figures and vice versa for girls. Each child was required to first choose which picture was most like him or her (i.e. “this child is pretty good at *throwing*, this child is not that good at *throwing*, which child is like you?”) and then needed to decide between two further options. For the ‘good’ picture the child decided between: ‘really good at… [score of 4]’ or ‘pretty good at… [3]’, and for the ‘poor’ picture the child decided between: ‘not that good at… [1]’ or ‘sort of good at… [2]’; resulting in four possible options for each item. Scores were summed into a POC score (range 6–24).

Covariates

At the time of consent, the responding parent also returned their child's sex, date of birth, weekly AVG game play time (*any* AVG play i.e. not necessarily sport games) and enrolment in organised sports/activities outside of school (school term preceding the study and also the current term). Each listed sport/activity was coded as either a ‘ball sport’ (e.g. golf, tennis, football, soccer) or ‘non-ball sport’ (e.g. swimming, martial arts; yes = 1, no = 0). Post-test, parents were asked again about their child's weekly time in AVG play during the study period (but not including the after-school intervention sessions).

Qualitative data collection

After intervention completion, seven focus group discussions were conducted with intervention children in order to explore factors influencing participation and outcomes. Discussions were facilitated by two members of the research team using a draw and write exercise (Knowles et al., 2013) and using a semi-structured topic guide to enable exploration and peer discussion of participation in the AVG intervention. For example, as discussion prompts, children were asked to draw pictures illustrating what they liked and did not like about participating in the intervention and then to reflect on their perceived sports competence and the transferability of any skills developed.

Recruitment, ethics, consent and permissions

Sample size calculations were based on the OC scores (mean = 26.5 ± 8.7) of similar aged children in a previous study conducted by the authors (Rosa et al., 2013). Based on 80% power, a significance value of 0.05, continuity correction and an expected positive outcome, the sample needed for the current study was 38 in each group to detect a 5 point difference in total OC score. Recruitment targeted 40 children in each group (80 in total). The target population was children in the first three years of formal schooling. Ethical approval was granted from the University Human Ethics Committee and the Department of Education and Early Childhood Development. Parents consented on behalf of the children.

A convenience sample of three elementary schools was recruited from Melbourne, Australia. The key inclusion criterion was children with limited AVG experience (<120 min/week using AVG). This is still well within the Australian electronic media recommendations (Australian Bureau of Statistics, 2013) and it was considered reasonable to assume that sports AVG play (which is what would be most likely to impact on current play) would be a substantially lesser component of this time.

A total of 119 parents consented; a consent rate of 23.3% (119/510). After consent, children who did not meet the inclusion criteria (n = 13) were excluded from the study.

Children were randomly allocated into intervention and control groups using matched subject design principles. Children at each school were sorted by school grade, child sex, and time in AVG play per week at baseline, and intervention or control status was allocated randomly within these subsets. Six children allocated to the intervention could not be accommodated at a time convenient for their parents and were re-allocated as control children prior to the intervention commencing. The final allocation was 60 children in the control group and 46 in the intervention condition.

Data analysis

Eleven children (six control and five intervention) were excluded from the analysis because at post-intervention parents stated their child had spent 120 min or more per week in AVG play at home during the study period; leaving 95 children from three schools. Descriptive statistics were calculated. Chi-square and independent t-tests were conducted to assess baseline differences between intervention and control groups in potential confounders (age, sex, ball sports experience, AVG experience).

Repeated measurements of OC and POC were analysed for the whole sample using linear mixed models. The mixed models included fixed effects for group (intervention or control), time (baseline or "pre" and "post") and their interaction. Random effects for school, child within school and assessment within child within school were included in the models but in analyses for which convergence to a solution did not occur, the school effect was removed from the model and replaced with independent effects for each child. The full model adjusted for sex, age, and prior ball sports experience. Exploratory moderating analyses was conducted separately for each sex, because the 4-way interaction (sex, group, time, prior ball sports) was significant for both OC and POC in the combined analysis. Predicted means, associated with effects judged to be significant by the F-test, were compared using t-tests. Unless otherwise stated, all tests were two-sided and conducted at the 5% significance level.

Group discussions lasted on average 18 min, were audio recorded and transcribed verbatim prior to thematic analysis [38]. NVIVO qualitative analysis software was used to facilitate data coding, management and retrieval for the qualitative data.

Results

Sample

The 95 children (55% girls; 43% in the intervention group) were aged 4 to 8 years (*M* 6.2, *SD* 0.95). Table 1 provides demographic and background sample information. No significant differences were observed between intervention and control children at baseline for age, sex, organised ball sports experience or AVG experience.

Intervention compliance and dose

Thirty-six (87.8%) intervention children attended the full six sessions, four missed one session and one child missed two sessions. The mean total intervention dose of AVG sports play was 278.4 min per child. Time each session was also spent on setting up the game, waiting for turns and administration (Table 2). Nearly all children (n = 40–41) tried Bowling, Frisbee and/or Disc Golf, Table Tennis, and Tennis. More time was spent Bowling (81 min), followed by Frisbee and/or Disc Golf (37 min), Golf (31 min), Table Tennis (26 min), Tennis (25 min), and Bocceball (19 min). Other games were played for 15 min or less each.

Table 1
Demographic and baseline data for control (n = 54) and intervention groups (n = 41).

Parent demographics		Control	Intervention
		N	N
Background	Born in Australia/UK/Ireland	35 (64.9%)	34 (83.0%)
	Born elsewhere	15 (27.8%)	4 (9.7%)
	English main language at home	46 (85.2%)	37 (90.2%)
	Missing	4 (7.4%)	3 (7.3%)
Employment	Full time paid	14 (25.9%)	7 (17.1%)
	Part-time paid	24 (44.4%)	13 (31.7%)
	Home duties	10 (18.5%)	14 (34.1%)
	Retired/other	1 (1.9%)	4 (9.7%)
	Missing	5 (9.3%)	3 (7.3%)
Education	University degree	45 (83.3%)	26 (63.4%)
	Technical/trade	2 (3.7%)	4 (9.8%)
	Year 12	3 (5.6%)	6 (14.6%)
	Some high school	0	2 (4.9%)
	Missing	4 (7.4%)	3 (7.3%)
Child information		**Control**	**Intervention**
		N	N
Male		21 (38.9%)	22 (53.7%)
AVG console at home		14 (25.9%)	7 (17.1%)
No prior time p/week playing AVG		40 (74.1%)	34 (82.9%)
15–90 min p/week playing AVG prior		14 (25.9%)	7 (17.1%)
Prior organised ball sport experience (no)		34 (63.0%)	25 (61.0%)
		M (*SD*)	*M* (*SD*)
Age (1 × 4 yrs, 25 × 5 yrs, 27 × 6 yrs, 36 × 7 yrs, 6 × 8 yrs)		6.3 (1.1)	6.1 (8.5)
Total weekly time in AVG prior		81.4 (32.1)	64.3 (25.6)
Perceived skill baseline		18.8 (3.4)	18.8 (3.7)
Actual skill baseline		31.2 (7.8)	30.4 (6.8)

Note. Potential differences between intervention and control tested (age, sex, ball sports experience, AVG experience). There were no significant differences found. Data collected in 2012 in Australia.

Table 2
A breakdown of time spent across all six (60 min/session) intervention sessions.

	M	*SD*	Range
Playing games with OC skills	278.4	31.2	180–320
Setup time (including creating a 'Mii')	40.6	8.5	25–55
Waiting for a turn	15.1	14.6	0–60
Other (e.g. bathroom)	14.8	21.6	0–135
Administration (e.g. marking names on roll)	2.3	4.2	0–20

Note. A 'Mii' is a Wii character/avatar. Data collected in 2012 in Australia.

Intervention effects on actual OC

In Model 1 (adjusted only for sex), OC improved over time from 31.06 to 32.68 ($p = 0.006$) but the intervention did not improve OC skill to a greater extent than the control ($p = 0.913$) (predicted means: control 31.80 to 33.53, SED = 0.748; intervention 30.33 to 31.83, SED = 0.835) (not shown in a table).

Whilst the three-way interaction of sex, group and time was not significant ($p = 0.079$), pairwise comparisons indicated a significant improvement in the girls in the intervention group (predicted means: 29.11 to 32.47, $p = 0.007$) and a significant difference between the groups, in the boys, at the "post" time point (predicted means: 36.10 in the control group and 31.18 in the intervention group, $p = 0.032$) (Table 3).

In Model 2 (adjusted for age, prior ball sports experience and sex) there was also no evidence of the intervention improving OC skill (Table 4). Exploratory moderating analyses (not shown in a table) were conducted separately for each sex, because the 4-way interaction

Table 3
Three-way predicted means (sex by group by time) for OC and POC (unadjusted model).

Object control skill			All children			
Sex	Group	n	Pre	Post	SED	*p*-Value
Boys	Control	21	34.24	36.10	1.16	0.114
	Intervention	22	31.55	31.18	1.14	0.750
	SED		2.26	2.26		
	p-Value		0.237	**0.032**		
Girls	Control	32	29.37	30.97	0.94	0.092
	Intervention	19	29.11	32.47	1.22	**0.007**
	SED		2.14	2.14		
	p-Value		0.903	0.483		0.079
Perceived object control			**All children**			
Sex	Group	n	Pre	Post	SED	*p*-Value
Boys	Control	21	20.52	20.38	0.57	0.801
	Intervention	22	20.23	20.14	0.55	0.869
	SED		1.03	1.03		
	p-Value		0.775	0.813		
Girls	Control	32	17.64	16.97	0.45	0.143
	Intervention	19	17.11	17.63	0.60	0.379
	SED		0.98	0.98		
	p-Value		0.587	0.499		0.297

Note. *p*-Values refer to pairwise t-tests apart from the *p*-value in the lower right hand corner of each sub-table which refers to the outcome of an F-test for the three-way interaction. Significant p values are bolded. SED = Standard Error of the Difference of an associated pair of means. Data collected in 2012 in Australia.

Table 4
Three-way predicted means (prior ball sports experience by group by time) for OC and POC.

Object control skill			All children			
Time			Pre	Post		
Ball sports	Group	n			SED	*p*-Value
No	Control	34	29.68	31.03	0.95	0.158
	Intervention	25	29.62	30.22	1.09	0.584
	SED		1.77	1.76		
	p-Value		0.97	0.65		
Yes	Control	19	33.17	35.33	1.25	0.088
	Intervention	16	32.61	35.18	1.36	0.063
	SED		2.28	2.28		
	p-Value		0.807	0.946		0.624
Perceived object control			All children			
Time			Pre	Post		
Ball sports	Group	n			SED	*p*-Value
No	Control	34	18.29	17.76	0.44	0.237
	Intervention	25	17.89	18.33	0.52	0.398
	SED		0.96	0.958		
	p-Value		0.67	0.557		
Yes	Control	19	19.54	19.02	0.59	0.378
	Intervention	16	20.10	19.91	0.65	0.773
	SED		1.24	1.24		
	p-Value		0.653	0.471		0.572

Note. All models adjusted for sex, age (months) and prior ball sports (yes/no). *p*-Values refer to pairwise t-tests apart from the *p*-value in the lower right hand corner of each sub-table which refers to the outcome of an F-test for the three-way interaction. SED = Standard Error of the Difference of an associated pair of means. Data collected in 2012 in Australia.

(sex, group, time, prior ball sports) was significant for OC ($p = 0.020$). For girls, the predicted means from the mixed model that included the three covariates showed there was a small but significant increase over time in the subset of the control group without prior ball sports experience (28.00 pre to 31.29 post, $p = 0.018$) and a significant increase in the subset of the intervention group with prior ball sports experience (28.64 pre to 35.98 post, $p = 0.003$). In the girls with prior ball sports experience, the difference between the groups was approaching significance ($p = 0.054$) at the post-intervention time point. For boys, there was no evidence of improvement in either the group with or without ball sports experience. All analyses were also run with and without the six children who were allocated to the intervention and were then re-allocated as control children and there was no difference in results (not shown).

Intervention effects on POC competence

In Model 1 (adjusted only for sex) there was no evidence of improvement in POC over time ($p = 0.503$) or significant differences between the groups in their changes over time ($p = 0.231$) (predicted means control: 19.08 to 18.68, SED = 0.362, intervention 18.67 to 18.88, SED = 0.406). Furthermore, pairwise comparisons indicated no difference between the groups, for girls or boys (Table 3). In Model 2 (adjusted for age, prior ball sports experience and sex), there was also no evidence of the intervention improving POC skill (Table 4). Exploratory moderating analyses were again conducted separately for each sex, because the 4-way interaction (sex, group, time, prior ball sports) was significant for POC ($p = 0.029$). For girls, pairwise comparisons of the predicted means indicate a significant decline in POC in the 'no prior ball sports experience' subset of the control group (18.27 pre to 16.83 post, $p = 0.024$). For boys, there was no evidence of improvement or decline over time in either the group with or without ball sports experience. As per OC, the analyses were also run with and without the six children who were allocated to the intervention and then re-allocated as control children and there was also no difference in results.

Process evaluation: qualitative reflection on intervention participation

Overall, children reported finding participation enjoyable and fun. Children tended to favour AVGs containing a competitive element, whether playing against another player, or the clock, or via single-player games in which a scoring system operated, enabling individual performance monitoring:

> *I like table tennis because I beat my record.*

However, most children favoured games which they found relatively easy, and reported disliking losing competitive games. If the task was perceived as too difficult some children reported feeling frustrated and discouraged to continue:

> *Well, I didn't like the basketball that much because it was really hard to get in the hoop.*

Children's perceptions of the relationship between AVGs and their 'real life' equivalents varied. The majority acknowledged that there was an important difference between AVGs and 'real life' activities, where AVGs were recognised as an artificial and less physically demanding proxy for 'real life' activities:

> *In real life stuff would be really harder. Like, I play basketball and on the Wii it was like easy. In real life it's like a little bit harder.*

In terms of transferability to 'real world' activities, some children reported being motivated to try a 'real life' game that they had not played before as a consequence of trying the AVG version and finding it fun:

> *Table tennis…it looks so fun in real life. I want to play in real life.*

However, children held mixed perspectives on whether AVGs could or did assist in 'real life' skill development or sports competence. Some felt that the artificiality of the AVGs undermined their benefits in terms of 'real-life' skill acquisition:

> *I don't think it really helps you, because the Wii person moves and stuff, and when you actually play it in real life you aren't used to it and real you might do it bad or something, and you might not do as good job in Wii.*

Conversely, other children thought AVGs assisted their competence and skill development, either directly (e.g. *It helped with throwing, because well, well I was really bad, and now I'm really good*) or in terms of familiarisation with games' rules, i.e. *You would get to understand the game and know what the game's like…what you're going to be doing when you play it.*

In terms of recommendations for improvement of the intervention and its outcomes, children suggested coaching, introducing a wider range of games, and combining AVGs with 'real life' activity:

> *You could have a TV outside and if you were playing soccer or something, you could get the kids to have a soccer ball, and you see their hands out on the soccer ball, and they kick it when they do it on the Wii, with the Wii remote.*

Discussion

This study investigated whether a play-based AVG programme increased children's actual and perceived OC skills. We found overall that there was no significant effect for the intervention group. This is reflective of the qualitative data, where children found the intervention enjoyable and stimulating, but most did not perceive direct equivalence between AVG and 'real life' activities. In contrast, the only other intervention that has attempted to improve OC skill through AVG use did find skill improved. One difference between the two approaches was that we investigated whether 'play' improved skill; therefore the children were not given instructions and could play what they wanted (within the given games). Whereas the programme by Vernadakis and colleagues had an experienced motor skill instructor who provided instruction on how to perform the necessary movements in each game and conducted sessions as per a lesson, i.e. with warm up, cool down and focus skills each session (Vernadakis et al., 2015). This has important implications, as it means AVGs may not have potential for skill acquisition in typically developing children unless they are used as a tool within a structured movement skill intervention. The other key difference was that the coaching intervention by Vernadakis et al. (2015) ran for eight weeks, twice a week for 30 min (total amount of instruction reported as 480 min). Our intervention 'dose' was substantially lower than this (278 min), so it could be that the dose was not sufficient to elicit an effect. It is challenging with AVG research to keep children engaged for extended periods. The very nature of electronic media is that children want variety. In this sense we believe we have tested a likely real world application of playing these games.

There may also be better potential for skill acquisition via different consoles. This study used the Nintendo Wii whereas the other study used the X-Box Kinect (Vernadakis et al., 2015). The Nintendo Wii requires the use of a handheld controller, which may lessen the opportunity for movement whereas the XBox Kinect is sensor based and controlled by both upper and lower body movements (Peng et al., 2013). When using the Nintendo Wii, movement skills may not need to be executed correctly (e.g., flicking wrist for a strike in tennis) for the controller to perform the required game action.

However we also found that many children acknowledged that some games could assist in skill development and transfer to increased sports competence. This finding corroborates previous qualitative research in older children (aged 9–10 years) which found children used AVGs as a learning tool for movement skill and considered skill acquisition was transferable between AVG play and real-life (Barnett et al., 2014b). This reciprocity is reflected in the findings of a large recent quantitative study (1490 adolescents) in which a bidirectional association between sports AVG play and sports involvement over four years was found (Adachi and Willoughby, 2014). This highlights that sports experience might be a crucial factor to understand when assessing the impact of a sports AVG intervention.

In the current study prior ball sports experience was a confounding factor. The exploratory data analysis revealed a small increase over time in control girls without prior ball sports experience and a large increase in OC skill for intervention girls with prior ball sports experience. As girls tend to have poorer ball handling skills than boys (Barnett et al., 2010, 2015a; Hardy et al., 2013) this finding suggests that AVG play may benefit girls who have also had real life ball sport experience.

The strengths of this study include the matched design, strong reliability and validity in instrumentation, and the fact that it was conducted in a real world play environment. In addition, collection of process evaluation qualitative data allowed in-depth exploration and elaboration of children's experiences of the programme. A limitation is that due to the confounding effect of prior ball sports experience and sex combinations of factors are in some cases based on a small number of individuals. A further limitation is that the skills assessed as part of the TGMD-2 did not always match the skill execution in the game. For instance the TGMD-2 assesses a baseball strike which is suitable for Wii baseball but not as suitable for a strike in tennis.

Conclusions

AVGs have been suggested as potentially appropriate to be used in school physical education programmes (Hayes and Silberman, 2007; Papastergiou, 2009; Staiano and Calvert, 2011), and as a strategy for overweight/obese and/or sedentary children to be more active (O'Loughlin et al., 2012; Peng et al., 2013). Whilst AVG play may help introduce children to sport, spending 1 h/week for 6 weeks is unlikely to build skills of typically developing children. Further research with different consoles, in a coaching context and with a higher dose may yield different results. At this point there is not sufficient evidence to suggest to parents, teachers and sporting organisations that a play-based AVG programme will develop movement skill therefore implications for health may be limited.

Authors' contributions

LMB conceived of the study, carried out the study, contributed to analysis and drafted the manuscript. NDR participated in the study design and helped to draft the manuscript. JR carried out the analysis and helped to draft the manuscript. LH led the qualitative research component and helped to draft the manuscript. JS participated in the study design advised on analysis and helped to draft the manuscript. All authors read and approved the final manuscript.

Conflict of interest statement

The authors declare that there are no conflicts of interests.

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