

Investigating intention to use as a mediator of associations between behavioural determinants and caregiver engagement with a parenting chatbot in South Africa

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Abstract

Background

Despite potential benefits of delivering digital health interventions (DHIs), engagement rates remain low. This study adopted the Digital Health Engagement Model to investigate how intention mediates the influence of behavioural determinants on caregivers' engagement with ParentText, a parenting chatbot designed to promote positive parenting and improve adolescent health.

Methods

Data included caregiver-reported baseline demographics (N = 1,034 caregivers of adolescent girls ages 10–17), intentions (to use and spend mobile data on the chatbot), and behavioural determinants collected at baseline. Engagement data were digitally tracked and recorded from August to December 2023. Structural Equation models were conducted to investigate the mediator effects of pre-intervention intentions in the relationship between baseline behavioural determinants and engagement.

Results

Results from structural equation models indicate that more favourable behavioural determinants predict higher enrolment (OR = 1.06, 95% CI: 1.01–1.10), higher module (β = 1.69, 95% CI: 0.47–2.91), goal (β = 1.30, 95% CI: 0.37–2.23) and more days interacting with the chatbot (β = 1.38, 95% CI: 0.30–2.46). There was no evidence of mediation by intentions. Despite limited internet access, caregivers with stronger intentions to use the chatbot were more likely to enrol. Despite analyses indicating behavioural determinants as a predictor of engagement, model fit results suggests that variation in caregivers' engagement with the chatbot is influenced by unmeasured factors rather than behavioural determinants or intention outcomes.

Conclusions

This is the first study to employ a behavioural science approach in understanding user engagement in a chatbot-led parenting programme. Our results highlight the importance of developing low-bandwidth DHIs to optimally engage digitally excluded populations, as well as adopting a qualitative approach to identify the factors driving user engagement in DHIs. Our findings further underscore the relevance of longitudinal research investigating the temporal stability of intention to better understand its predictive significance for user engagement in digital parenting interventions.

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Introduction

Digital delivery platforms have the potential to support the implementation of tailored interventions to improve public health (1, 2). They are potentially cost-effective solutions to addressing some of the

logistical and financial barriers of delivering in-person public health programmes at scale. Digital interventions, including those delivered via chatbots, have shown promise in improving health knowledge, reducing health risks (3) and promoting beneficial behavioural changes such as positive parenting (4). However, user engagement with digital health interventions (DHIs) remains a challenge with low participation rates (5). A systematic review of 41 studies from high income countries (HICs) reported at least one-fifth of participants in short-duration mental health interventions (lasting ≤ 8 weeks) delivered via conversational agents discontinued participation. Notably, even higher dropout rates were observed for interventions that extended beyond eight weeks (5).

There is modest evidence on the design aspects of DHIs (i.e., provision of tailored feedback and reward, provision of prompts and reminders) that contribute to engagement (6). Behavioural determinants, defined as individual and societal characteristics that could facilitate users' uptake of DHIs, provide a broader perspective to pathways towards user engagement (7). However, there is limited evidence on how behavioural determinants such as individual characteristics (e.g., perceived usefulness and ease of use of DHIs) and structural factors (e.g., costs and institutional resources supporting the use of DHIs) motivate individuals to use DHIs leading to greater engagement (8).

Barriers and Facilitators to User Engagement in DHIs

Sociodemographic characteristics (such as age, income and education) and DHI attributes have been associated with user engagement in DHIs (9). For instance, users within low socioeconomic groups display greater likelihood of inactivity in DHIs (10). Similarly, DHIs' related attributes, such as unstructured content (content that follows an open and non-sequential design) and diversified delivery modes, were associated with higher user engagement (11).

Further investigation is warranted to understand how behavioural determinants such as individual perceptions of DHIs and structural factors predict engagement with chatbot-led interventions (8). Additionally, most research on factors associated with lower user engagement (e.g., difficulties in using technology, busyness due to demanding careers or caring responsibilities, the impersonal nature of chatbots, and financial worries) in chatbot-led public health interventions has been conducted in high-income countries, which leaves a gap to understanding the factors associated with user engagement with DHIs implemented in low- and middle- income countries (LMICs) (12).

Chatbot-led Parenting Interventions in South Africa

LMICs including South Africa, have experienced a steady increase in mobile phone use over the past decade, which has offered an opportunity to deploy chatbot-led programmes focusing on behaviour change (13). The implementation of chatbot-led programmes for pre-and post-natal health education and intimate partner violence prevention has been proven feasible in South Africa (14, 15). Importantly, while in-person parenting programmes in South Africa have shown improved caregiving behaviours and reduced adolescents' exposure to maltreatment and risk for early pregnancy and HIV-infection (16), the scale-up of these programmes has been limited by the human and financial resources required for sustained delivery

(17). As a result, digital interventions such as chatbots may offer a more accessible alternative by increasing access for caregivers (i.e., reducing barriers due to travel, childcare, work commitments) while also reducing the burden on service delivery systems (18).

To date, no studies have specifically examined user engagement with parenting chatbots in LMIC contexts like South Africa or adopted a behavioural science approach to understand the engagement process (4). Yet, caregiver engagement with such chatbot-led parenting programmes may play a crucial role in shaping parenting behaviours and beliefs, ultimately fostering healthier parent-child relationships. On the other hand, if caregivers face barriers to engagement, chatbot-led interventions are unlikely to influence behaviour change, thereby limiting its ability to improve child health and well-being. Hence, this study aimed to investigate how behavioural determinants and intentions are associated with caregivers' engagement with a parenting chatbot delivered in rural and peri-urban communities in South Africa.

Theoretical Background and Determinants of Engagement

This study uses the Digital Health Engagement Model (DHEM), a model that investigates how behavioural determinants and intentions influence user engagement in DHIs to investigate the pre- and post-intentional stages of the engagement process (7). According to the DHEM, behaviour change occurs in two stages, a) pre-intentional that culminates with intention to use the DHI and b) post-intentional that culminates with actual engagement. In the pre-intentional stage, behavioural determinants contribute to goal setting (intention), whereas in the post-intentional stage, there is a mindset transition to goal pursuit and actual usage of the DHI. The O'Brien & Toms' conceptual framework proposes the evaluation of four key engagement stages: 1) point of engagement (enrolment in the DHI), 2) sustained engagement (driven by content or design), 3) disengagement (due to internal or external factors), and 4) re-engagement (reconnection and continue interaction) (19).

Our study specifically examined factors contributing to the point of engagement and sustained engagement as a critical stage in the delivery of digital parenting interventions. While there are multiple approaches to operationalizing measurements of sustained engagement in DHI research, there are two main prevalent categories: frequency or duration of usage (e.g., total number or percentage of activities and modules completed) and adherence (e.g., proportion of content accessed or the number of days or weeks of interaction with the DHI) (8).

The DHEM was selected over other existing digital health frameworks because it offers a comprehensive construct of behavioural determinants across multiple domains, including social influence, attitude, habit, perceived usefulness and ease of use, hedonic motivation, and price value. Furthermore, DHEM facilitates a multidimensional examination of how user intention (i.e., intention to use, spend time and money) mediates the relationship between behavioural determinants and user engagement in DHIs. This broader scope is particularly valuable in low-income contexts, where economic status might influence user engagement with DHIs.

Objectives

This study aims to examine how pre-intervention intentions mediates the relationship between behavioural determinants and the engagement of caregivers (i.e., enrolment status, modules, goals, home activity initiated and completed, and number of days interacting) in a chatbot-led parenting intervention.

Methods

Study Design, Setting and Eligibility Criteria

This study was nested within a 2 x 2 factorial trial that aimed to optimise user engagement in a chatbot-led parenting intervention implemented by mother2mothers (m2m), a South African not-for-profit organisation (20). Demographics, behavioural determinants and intentions data were collected at baseline and digitally tracked engagement data were recorded from August to December 2023. The study was implemented primarily in low-income rural and peri-urban areas in Mpumalanga, South Africa, where agriculture, fishing, and mining are the main economic sectors. Thirty-two clusters were randomly assigned to receive one of the four engagement packages. Within the context of the factorial study, participants in the thirty-two clusters were either assigned to 1) ParentText chatbot parenting courses delivered via WhatsApp plus an in-person onboarding session, 2) ParentText, onboarding, and three additional in-person sessions for parents and teens, 3) ParentText, onboarding, and six facilitated WhatsApp support groups sessions, or 4) ParentText, onboarding, three additional in-person sessions, and six facilitated WhatsApp support groups. The intervention was delivered as part of the large-scale national strategy programme Children and Adolescents Are My Priority (CHAMP) that provided support to 28,500 adolescent girls and young women by addressing structural inequalities (across health and education), and providing HIV biomedical prevention resources (21).

This study included caregivers 1) aged 18 years or older caring for an adolescent girl aged between 10 and 17 years. The complete criteria for eligibility are described in the published protocol (20). Ethics approval for this study was provided by review committees in South Africa (R69569/RE003) and the UK (R88177/RE001) for the protection of human participants.

Data Collection Procedures

Participants were invited by m2m to participate and provided written informed consent before enrolling in the study and completing paper-based baseline surveys. Trained community facilitators guided caregivers and their adolescent girls through an in-person onboarding session which included registration in the chatbot and a 10-minute demonstration of how to interact with the chatbot. At the end of this onboarding session, participants completed the demographics, behavioural determinants and intentions survey. They were then randomly assigned to one of the four engagement package groups [one in-person session, four in-person sessions, one in-person session combined with a WhatsApp support group, and four in-person sessions combined with a WhatsApp support group]. Engagement data were digitally tracked through the chatbot. Further information on the data collection and randomisation procedures can be found in the study protocol (20).

The ParentText Digital Health Intervention

ParentText is a rule-based chatbot developed by Parenting for Lifelong Health which aims to promote positive parenting behaviour and to improve adolescent health (20). Building on the evidence from the initial pilot of ParentText in South Africa in 2022, which showed that less than one-third (20% to 28%) of participants accessed the content delivered across four topics, the chatbot content and design underwent iterative refinement to improve engagement (22). The chatbot delivered daily unstructured learning modules which includes: a) introduction of key topic or parenting skill, b) true/false quiz to facilitate knowledge transfer, c) illustrated comics modelling parenting skill, d) videos explaining how to use the specific parenting skill, and e) assignment of home practice to apply the skill with adolescents.

The core intervention in ParentText consists of 37 modules grounded in evidence-based practice, covering topics such as adolescent healthy development, academic support, safety in the community and relationships, and family finances (7). For instance, the modules on strengthening caregiver–adolescent relationships include techniques for spending quality one-on-one time with adolescents. Modules on adolescent development offer strategies for recognising and managing signs of stress, and guidance for discussing reproductive health. ParentText also includes a safeguarding system linked to specific trigger words with a referral process. Daily engagement trigger messages are sent to participants after 23.5 and 48 hours of inactivity. Participants who remain inactive for 72 hours, are no longer prompted to engage but could reengage themselves at any point thereafter.

Measures

The DHEM informed the conceptualization on how behavioural determinants and intentions contribute to the mechanisms leading to engagement. We used the Overall Behavioural Determinants Scale, composed of 14 items across seven domains derived from the Technology Acceptance Model (23) and its extensions: perceived usefulness, perceived ease of use, attitude, hedonic motivation, habit, price value and social influence. The Overall Behavioural Determinants Scale is a composite index ranging from 0.67 to 18.64 with higher scores indicating more favourable determinants of user engagement in the DHI (7).

Two items measured intention: 1) intentions to use the chatbot and 2) intention to spend mobile data to access the chatbot. Items were assessed based on a 5-point Likert scale from “strongly disagree” (0) to “strongly agree” (4). The Overall Behavioural Determinants Scale demonstrated high internal consistency (Cronbach’s $\alpha = 0.90$ (95% CI: 0.89–0.90); $\Omega = 0.91$) and explained up to 37% of the changes in user’s intentions to use a chatbot-led parenting intervention (7).

Engagement outcomes include a single indicator of point of engagement – binary enrolment status, (yes/no) – and four measures of sustained engagement – the rate of modules, goals, and home activities completed, and the total number of days the caregiver interacted with the chatbot. The rate of modules completed was calculated for each participant as total number of modules completed divided by the total number of modules available. The same approach was used to calculate the rate of goals and home activities completed. The total number of days of engagement was estimated by counting the number of

days between enrolment and the recorded last day of interaction with ParentText. Due to the challenges of tracking engagement with home activities, we asked participants to self-report completion rates on the chatbot manually.

Covariates included participant demographic characteristic and human-led components. Demographic measures included age, measured in years, sex, categorized as male or female, and financial efficacy, ranging from “not at all true” (0) to “exactly true” (3). Human-led components were effect-coded dummy variables, with caregivers coded as – 1 if not assigned and 1 if assigned to receive the in-person or WhatsApp remote support group sessions.

Statistical Analyses

Descriptive statistics and regression tests were conducted using R (R version 4.2.2) software. To account for missing baseline data (a maximum of 10% for predictors, $n = 108$), multiple imputation-chained equations were conducted using fully conditional specifications, with twenty imputations created accounting for clustered standard errors. In cases where data were not recorded for participants who did not engage with ParentText, these instances were treated as structural zeros. Pooled descriptive data were reported as frequencies and percentages for categorical variables and means and standard deviations for numeric variables.

Structural equation models (SEMs) were used to explore how baseline behavioural determinants and intentions are associated with engagement in the parenting chatbot. Although both behavioural determinants and intentions were measured at baseline, behavioural determinants are assumed to temporally precede intentions. For example, social influence – as reflected in caregivers’ perceptions of their peers’ opinions about the parenting chatbot – is expected to shape caregivers’ intention to use the chatbot, rather than the reverse. Firstly, the analysis investigated three sets of associations: 1) the association between behavioural determinants and engagement, 2) the association between behavioural determinants and intentions (7), and 3) the association between intentions and engagement. Secondly, based on the model results testing associations between intentions and engagement two SEMs were conducted testing how 1) intention to use mediates the relationship between behavioural determinants and enrolment in the chatbot and 2) intention to spend mobile data mediates the relationship between behavioural determinants and sustained engagement outcomes (e.g., modules, goals and number of days interacting) (24). Logistic regression models tested the associations between the behavioural determinants measure and enrolment, while linear regression models examined the associations between behavioural determinants and sustained engagement outcomes.

The indirect effect of behavioural determinants on engagement through intention was calculated by multiplying the product of the path coefficient of behavioural determinants on intention and intention on engagement outcomes. The total effect summed both direct and indirect effect coefficients. Path analysis was executed using the “lavaan” package. All analyses were clustered at the 32 regions of the study and included covariate adjustment for age, sex, perceived financial efficacy, and human-led components. The Multiple Imputation Boot approach was adopted (25). To evaluate model stability and adequacy, each

model was bootstrapped within all 20 imputed datasets by generating 1,000 resampled datasets, created through random sampling with replacement from the original sample (26). Bootstrap percentile confidence intervals were estimated for each model using the *boot.ci()* function in the *boot* package in R, with percentile limits defined as the $\alpha/2$ (0.025) and $1 - \alpha/2$ (0.975) quantiles of the bootstrap distribution. Estimates from the twenty imputed datasets were pooled using the mean regression coefficient and the corresponding bootstrap percentile confidence intervals. Rubin's rules (27) were used to calculate pooled standard errors, and p-values. STROBE checklist was followed in reporting results (28).

Results

Descriptive Summary

Of the 1,464 caregivers recruited and enrolled into the study, 1,034 were matched to their baseline demographic and behavioural determinant surveys and digitally tracked engagement data (Fig. 1). Study participants are 38 (SD 9) years on average and 94.19% (974/1034) are female caregivers (Table 1). Out of the 1,034 caregivers enrolled in the study, 646 initiated engagement with the ParentText chatbot (62.47%). On average, caregivers assigned to receive facilitated WhatsApp support groups attended 41.66% (2.5/6) of the sessions. The verified attendance for the onboarding session was 100% (1/1), and the average attendance for the three additional in-person sessions was 66.00% (2/3) across those assigned to receive them. Caregivers completed on average 20.83% (SD 34.26%) of modules, 13.15% (SD 28.64%) of goals, 2.46% (SD 5.98%) of home activities and interacted with the chatbot for 25.38 days (SD 37.66). Languages used to interact with ParentText include English, 80.09% (518 / 646), isiZulu, 10.38% (67 / 646) and siSwati, 9.51% (61 / 646).

Table 1
Pooled demographics and engagement summary across study population

Demographic Characteristic	N = 1,034
Caregiver age, mean (SD)	38 (9)
Place of residence, n (%)	716 (69.24)
Ehlanzeni	318 (30.75)
Nkangala	
Female caregiver, n (%)	974 (94.19)
Biological parent, n (%)	847 (81.91)
In a partnered relationship ^a , n (%)	665 (64.31)
Perceived Financial efficacy ^b , mean (SD)	1.64/3 (1.09)
Presence of father in the house, n (%)	372 (35.97)
Yes	125 (12.08)
Passed away	537 (51.93)
Lived elsewhere	
Caregiver disability ^c , n (%)	76 (7.35)
Child age, mean (SD)	12 (2.00)
Female child, n (%)	1,034 (100.0)
Adolescent school enrolment, n (%)	867 (83.84)
Grade 4–9	167 (16.15)
Grade 10–12	
Caregiver anxiety and depression, mean (SD)	3.39/12 (3.21)
Caregiver stress, mean (SD)	8.60/20 (4.21)
Enrolled in ParentText, n (%)	646 (62.47%)
Modules completed, mean (SD)	20.83 (34.26%)
Goals completed, mean (SD)	13.15 (28.64%)
Home activity completed, mean (SD)	2.46 (5.98%)
Number of days interacting, mean (SD)	25.38 (37.66)

^a Partnered refers to married, civil or non-civil partnership status.

^b Higher values indicate perceived greater capacity to manage finances.

^c Includes caregiver-reported cognitive, learning, auditory, visual, physical (any motor limitations and difficulties in performing self-care activities such as getting dressed) and functional disabilities (any pre-existing non-communicable health conditions such as diabetes, cardiovascular disease and cancer).

Linear Regression Analysis

Results from the first step relationship indicate that more favourable behavioural determinants were significantly associated with higher enrolment (OR = 1.10, 95%CI: 1.05–1.16), and with three measures of sustained engagement: number of modules completed (β = 1.66, 95%CI: 0.88–2.50), goals completed (β = 1.32, 95%CI: 0.68–1.95), and number of days interacting with ParentText (β = 1.44, 95%CI: 0.51–2.28). Behavioural determinants were also significantly associated with both intention to use ParentText (OR = 1.85, 95%CI: 1.80–1.89) and intention to spend mobile data (OR = 1.76, 95%CI: 1.72–1.81) (7).

Intention to use was significantly associated with higher enrolment (β = 1.20, 95% CI: 1.01–1.39) while intention to spend mobile data was significantly associated with three measures of sustained engagement: the rate of modules (β = 3.49, 95%CI: 0.76–6.18) and goals completed (β = 3.34, 95%CI: 1.10–5.26), and the number of days caregivers interacted with the chatbot (β = 3.58, 95%CI: 0.70–6.29). However, no significant associations were observed between behavioural determinants, intention to spend mobile data and home activity and intention to use and any of the sustained engagement outcomes (Table 2). Regression model results across the 20 imputed datasets are reported in Supplementary File 1 (Table S1, Table S2, Table S3, Table S4, Table S5, Table S6, Table S7, Table S8, Table S9, Table S10, Table S11, Table S12, Table S13, Table S14, Table S15, Table S16, Table S17, Table S18, Table S19 and Table S20). Goodness of fit results indicate average R-squared values ranging from 0.6% to 2% for the overall behavioral determinants, and the intention to use and spend mobile data regression models, suggesting that other factors not included in the model drive engagement (Supplementary File 1, Table S41, Table S42, Table S43, Table S44, Table S45, Table S46, Table S47, Table S48, Table S49, Table S50, Table S51, Table S52, Table S53, Table S54, Table S55, Table S56, Table S57, Table S58, Table S59 and Table S60).

Structural Equation Models

Results from the second step of analysis indicate that overall behavioural determinants directly influenced enrolment and sustained engagement outcomes: number of modules and goals completed and number of days interacting with ParentText; however, the mediation effect of intention to spend mobile data is not observed for any of the engagement outcomes (Table 3, Fig. 2). Structural Equation Model results across the 20 imputed datasets are reported in Supplementary File 1 (Table S20, Table S21, Table S22, Table S23, Table S24, Table S25, Table S26, Table S27, Table S28, Table S29, Table S30, Table S31, Table S32, Table S33, Table S34, Table S35, Table S36, Table S37, Table S38, Table S39, Table S40). Tables S61, S62, S63 and S64 of the Supplementary File 2 report the results of steps one and two of the analysis conducted on the complete enrolled cases for sensitivity analysis.

Table 2

Regression and bootstrap model estimates for the effects of overall behavioural determinants and intentions on caregiver's sustained engagement with ParentText

Engagement Outcomes	Behavioural determinants			Intention to use in the future			Intention to spend mobile data		
	Pooled Bootstrap			Pooled Bootstrap			Pooled Bootstrap		
	Coefficients			Coefficients			Coefficients		
	OR / β	CI	p	OR / β	CI	p	OR / β	CI	p
Point of Engagement ^a									
Enrolment	1.10 (0.03)	1.05 – 1.16	.000	1.20 (0.09)	1.01 – 1.39	.043	1.13 (0.08)	1.13 – 1.13	.104
Sustained Engagement ^b									
Modules completed	1.66 (0.41)	0.88 – 2.50	.000	0.96 (1.67)	-2.23 – 4.29	.566	3.49 (1.42)	0.76 – 6.18	.014
Goals completed	1.32 (0.32)	0.68 – 1.95	.000	0.86 (1.37)	-1.87 – 3.35	.532	3.34 (1.37)	1.10 – 5.26	.005
Home activity completed	0.14 (0.08)	-0.02 – 0.31	.088	0.03 (0.30)	-0.53 – 0.62	.907	0.16 (0.26)	-0.34 – 0.64	.679
Number of days interacting	1.44 (0.45)	0.51 – 2.28	.001	2.29 (1.92)	-1.39 – 5.56	.233	3.58 (1.47)	0.70 – 6.29	.014
Note: Mean regression coefficients with bootstrap percentile 95% CI; Rubin-pooled standard errors, and p-values. Standard errors in brackets. All models are adjusted for age, gender and financial efficacy and human-led components; a) Odds ratio coefficient; b) β coefficient.									

Table 3

Pooled path coefficients of behavioural determinants effects on engagement outcomes mediated by intention to use and spend mobile data on the chatbot ParentText.

		Direct			Total indirect			Total direct		
		Pooled Bootstrap			Pooled Bootstrap			Pooled Bootstrap		
		Coefficients			Coefficients			Coefficients		
		OR / β	CI	p- VALUE	OR / β	CI	p- VALUE	OR / β	CI	p- VALUE
Point of Engagement ^a										
Enrolment Status	I1	1.06 (0.01)	0.99– 1.01	.000	1.00 (0.00)	0.99– 1.01	.902	1.06 (0.01)	1.01– 1.10	.000
Sustained engagement ^b										
Modules completed	I2	1.48 (0.70)	0.12– 2.85	.033	0.20 (0.34)	-0.46– 0.87	.559	1.69 (0.62)	0.47– 2.91	.006
Goals completed	I2	1.04 (0.49)	0.09– 1.98	.034	0.26 (0.26)	-0.23– 0.75	.325	1.30 (0.47)	0.37– 2.23	.005
Number of days interacting	I2	1.02 (0.66)	-0.25– 2.31	.121	0.35 (0.35)	-0.32– 1.03	.319	1.38 (0.54)	0.30– 2.46	.011
Note: Path coefficients of a combined model of sustained engagement outcomes and an individual model of point of engagement. Mean regression coefficients with bootstrap percentile 95% CI; Rubin-pooled standard errors, and p-values. Standard errors in brackets. All models are adjusted for age, gender, self-efficacy and engagement boosters. a) Odds Ratio. b) β coefficient. I1: intention to use. I2: intention to spend mobile data.										

Discussion

This study investigates the mediating role of intention in the relationship between behavioural determinants and caregiver engagement with a chatbot-led parenting intervention delivered in rural South African communities. Our findings indicate that behavioural determinants predicted enrolment and sustained engagement (modules and goals completed and number of days interacting) and explained a large percentage of variance for caregivers' intention to use and spend mobile data in the chatbot. While intention to spend mobile data predicted sustained engagement (modules and goals completed and number of days interacting), only intention to use predicted enrolment in the chatbot. Despite limited internet access, caregivers with stronger intentions to use the chatbot were more likely to enrol. In contrast, continuous engagement depended on their intention to spend mobile data on the chatbot. These findings underscore the importance of developing open-access, low-bandwidth DHIs to promote optimal utilisation among populations with limited internet connectivity.

We did not observe any mediation of associations between behavioural determinants and engagement by intentions. Our measurement may not have been sensitive enough to capture caregivers' intentions to use

ParentText in the future, thus future studies should investigate more refined measures of intentions. While unexpected, these findings are consistent with previous work suggesting a gap between intention and behaviour (29). The disjunction between both was reported in a meta-analysis of 10 studies that reported an intention-physical activity gap of 46% of intenders who did not act (30). The intention-behaviour gap was also observed in a North American digital mental health study despite the lack of evidence on how big it is across digital health studies (31). Even though most behavioural science theories propose that intention best predicts an individual's actual behaviour (32), in practice individuals' intentions are not necessarily translated into behaviours. In the context of this study, where women comprise 94.19% of the sample, it is essential to acknowledge the South African gender digital divide. Spatial analysis in South Africa has identified a 45.4% gender gap in internet access at home, with female and lower-income populations having less access to internet connectivity (33). Future research should further investigate how gender dynamics shape access to and use of DHIs to inform gender-intentional designs that consider gender norms, roles, and relations (34).

Digital health studies have reported that DHI's unstructured design, and provision of guidance result in increased engagement outcomes; however, it is unclear how much those explanatory factors explain variations in participants' engagement (11, 35). It is essential to acknowledge that, although the factors contributing to engagement are unclear, developing new frameworks to measure how, when, where, and with whom users plan to interact with DHIs could offer a more comprehensive understanding of the mechanisms underlying engagement.

Strengths and Limitations

The use of SEM has strengthened the rigor of our analysis in testing whether the associations between behavioural determinants and multiple engagement outcomes work in isolation or are mediated by intentions. The temporal sequence of events in data collection (i.e., baseline behavioural determinants and intention outcomes, and digitally tracked engagement throughout the intervention) also allowed for stronger evidence for a causal relationship between the behavioural determinants and engagement outcomes. However, there are several limitations to consider when interpreting our findings. Firstly, considering the linear design of the study, no post-test measurements of intention or behavioural determinants were collected. As such, it was not possible to explore whether participants' attitudes, beliefs and intentions towards engaging with the chatbot have matured or changed throughout the intervention. Future studies should include post-test measurements of intentions and behavioural determinants. Third, we were unable to match 161 participants with engagement outcomes to their baseline surveys due to incorrect reports of their study ID. However, the application of multiple imputation chained equations allowed the preservation of a large sample size. Fourth, relying on a dichotomous metric of module and goal completion rate might not have captured thoroughly the engagement levels of participants, as some might have interacted with part of the content despite not completing a full module or goal. Last, the provision of internet bundles worth 50 ZAR (approximately US \$2.60) might have skewed intentions outcomes in a more positive direction; as such, caution is required when generalizing study results to a broader population.

Conclusion

This is the first known study to investigate the mediating role of intentions in the influence of overall behavioural determinants on caregivers’ engagement in a chatbot-led parenting intervention delivered through a community-wide project aimed at multifaceted support in the context of high HIV prevalence. Our findings provide an essential understanding of the intention-behaviour gap and engagement-enhancing strategies when designing and implementing DHIs in low-income settings. It is crucial that developers and implementation scientists work alongside governments and internet providers to build strategies and policies to increase connectivity among populations at higher risks of digital exclusion.

Despite evidence of the role of behavioural determinants in explaining the observed changes in the pre-intention motivation stage (i.e., individual sets a goal to engage), our key findings suggest that none of the factors investigated could explain well the changes in the post-intention volition stage (i.e., mindset transition to pursue the goal and engage). Future research should adopt a qualitative approach for a more nuanced understanding of the behavioural determinants of engagement.

Abbreviations

DHIs: Digital Health Interventions
DHEM: Digital Health Engagement Model
STROBE: Strengthening the R eporting of O bservational S tudies in E pidemiology
LMIC: Low- and middle-income country
MOST: Multiphase Optimization Strategy
PLH: Parenting for Lifelong Health
CHAMP: Children and Adolescents Are My Priority

Declarations

Ethics approval and consent to participate

Ethics approval for this study was provided by the University of Cape Town Centre for Social Science Research Ethics Committee (reference: CSSR 2023/05), the University of Oxford Social Sciences and Humanities Interdivisional Research Ethics Committee (reference: R88177/RE001), and the Mpumalanga Department of Health and Department of Social Development (reference: R69569/RE003). All methods and procedures were carried out in accordance with the guidelines and regulations of the University of Oxford and the Mpumalanga Department of Health. Participants provided informed consent before enrolling in the study and completing paper-based baseline surveys.

Consent for publication

Not Applicable

Availability of data and materials

Due to ongoing analyses, the datasets used and analysed during the current study are not currently publicly available. They will be made available via the Open Science Framework registration of the ParentText Optimisation Study upon study completion. For the time being, datasets are available from the Principal Investigators on reasonable request.

Competing interests

JML is the CEO, and LM is the Chief of Solutions for PLH, a UK-based charitable organisation that developed ParentText, an open-access resource licensed under a Creative Commons 4.0 Attribution-Share-Alike license. JML participates in several research studies involving the programme as an investigator, and the University of Oxford and the University of Cape Town receive research funding for these. MDGA, JS, SL, ZM, FG, SV, HS, PZ, LM, and GJMT worked on other studies by PLH. The researchers will not benefit financially from implementing and disseminating this intervention. KB worked for Clowns Without Borders South Africa, a South African charitable organisation that provides capacity-building and technical support for the delivery of PLH programmes in Africa. The sponsor and funders were not involved and did not influence any stage of study design, execution, data analysis, or dissemination of results.

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Authors' Contributions

MDGA led study conceptualisation with contributions from SV, FG and JML. MDGA led data curation with contributions from JS and SL. AS, KB, SL, PZ, JS, ZM, HG, LM, DS, and CF conducted Project Implementation. Methodology development and formal analysis were led by MDGA, with GJMT, SV, FG and JML providing guidance on the analytical approach; Writing, editing of the original manuscript, and review were led by MDGA, with SV, JML and FG contributing. All authors approved the final manuscript.

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Figures

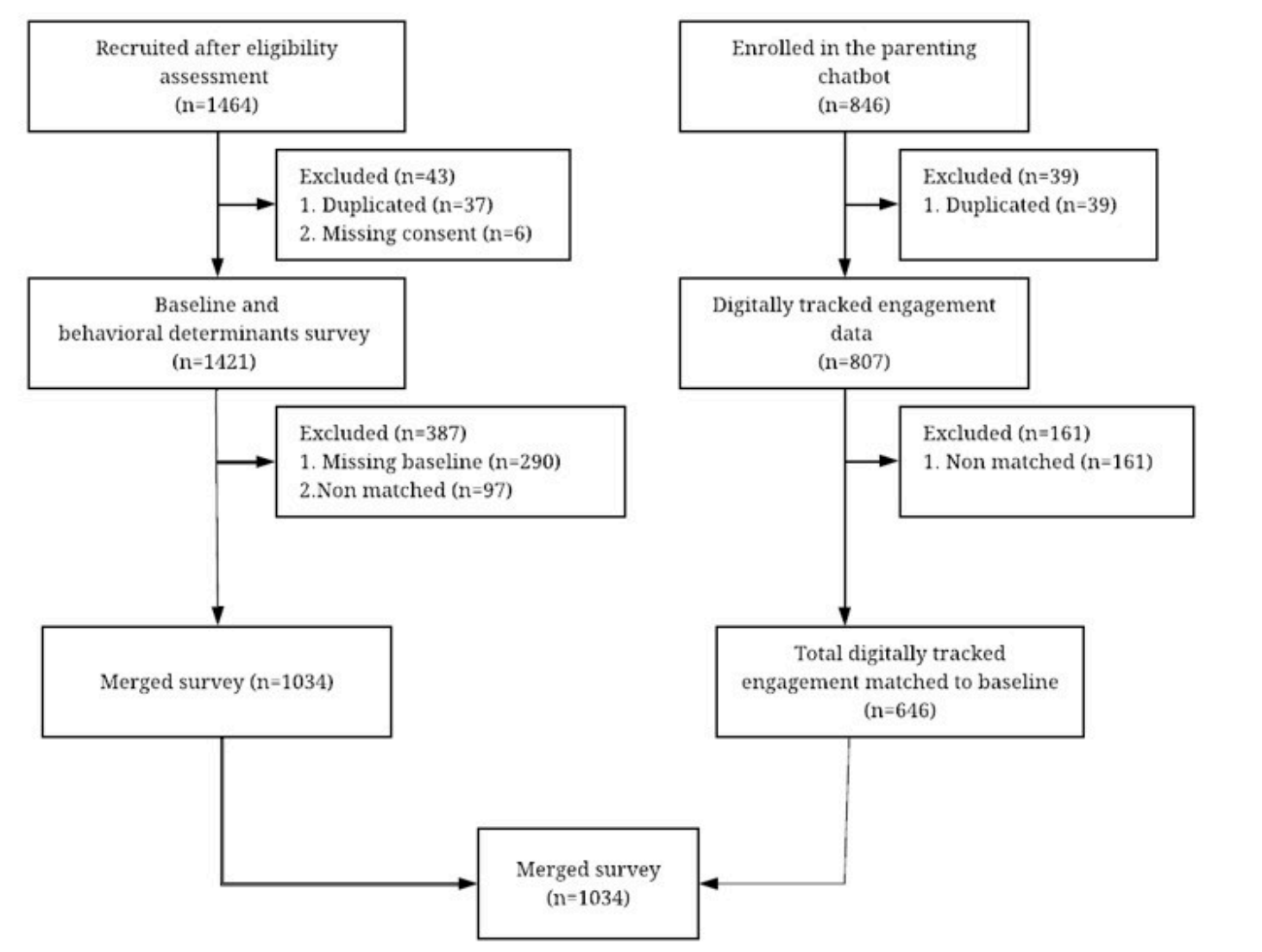
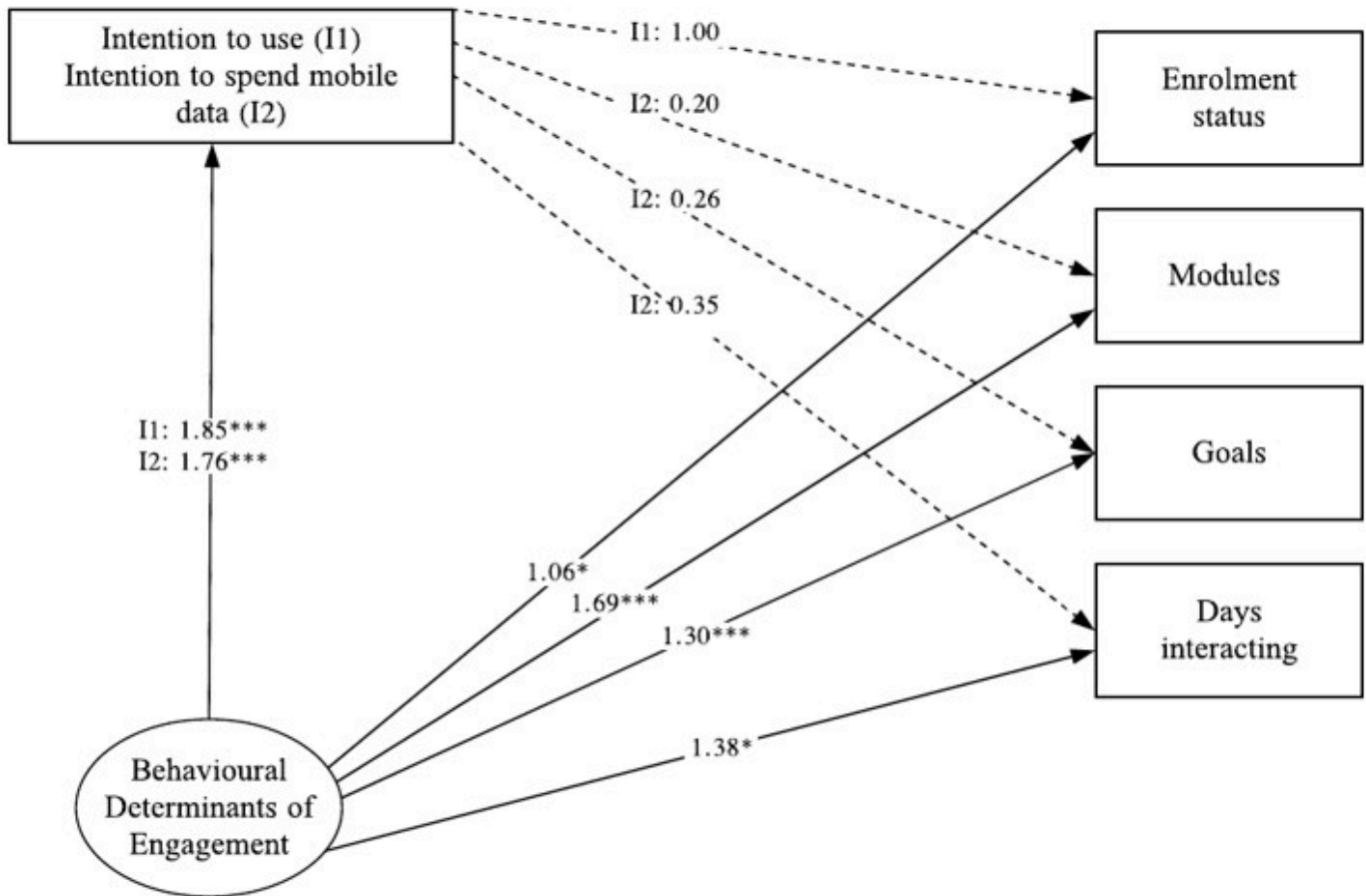


Figure 1

Study recruitment



Note: * <0.05, ** <0.01, *** <0.001; Solid lines displaying direct effects; Dashed lines displaying indirect effects. Path coefficients of a combined model of sustained engagement and individual model of point of engagement outcomes.

Figure 2

Pathway from the exogenous variable behavioural determinant to the outcome engagement through the mediator intention to spend mobile data.

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