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1 **Effectiveness and Acceptability of Conversational Agents for Sexual Health Promotion:**  
2 **A Systematic Review and Meta-Analysis**

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11

**Abstract**

12 Digital health interventions for sexual health promotion have evolved considerably alongside  
13 innovations in technology. Despite these efforts, studies have shown that they do not  
14 consistently result in the desired sexual health outcomes. This could be attributed to low levels  
15 of user engagement, which can hinder intervention effectiveness as users do not engage with  
16 the system enough to be exposed to the intervention components. It has been suggested that  
17 conversational agents have the potential to overcome the limitations of prior systems and  
18 promote user engagement through the increased interactivity offered by bidirectional, natural  
19 language-based interactions. The present review therefore provides an overview of the  
20 effectiveness and user acceptability of conversational agents for sexual health promotion. A  
21 systematic search of seven databases provided 4,534 records and after screening, 31 articles  
22 were included in this review. A narrative synthesis of results was conducted for effectiveness  
23 and acceptability outcomes, with the former supplemented by a meta-analysis conducted on a  
24 subset of studies. Findings provide preliminary support for the effectiveness of conversational  
25 agents for promoting sexual health, particularly treatment adherence. These conversational  
26 agents were found to be easy to use and useful, and importantly resulted in high levels of  
27 satisfaction, use and intentions to reuse, while user evaluations regarding the quality of  
28 information left room for improvement. The results can inform subsequent efforts to design  
29 and evaluate these interventions, and offer insight into additional user experience constructs  
30 identified outside of current technology acceptance models which can be incorporated into  
31 future theoretical developments.

32 *Keywords:* sexual health, review, meta-analysis, HIV, chatbot, conversational agent, mHealth,  
33 digital health intervention

## 34 **Introduction**

35 Digital health interventions (DHIs) are interventions delivered via digital technologies such as  
36 smartphones, websites, social media or text-messaging<sup>1</sup>. DHIs have become increasingly  
37 popular for large-scale health promotion efforts as an innovative, cost-effective, and scalable  
38 solution for addressing key public health challenges such as staff shortages and budget  
39 constraints. They can be especially suited for the sexual health domain because there is the  
40 potential to reach at-risk groups e.g. adolescents<sup>2</sup>, ethnic minorities<sup>3</sup>, sexual minorities<sup>4</sup>, illicit  
41 drug-users<sup>5,6</sup> and sex workers<sup>7,8</sup> are less likely to seek professional care due to limited  
42 resources, poor quality of services and stigmatization.

43 DHIs for sexual health promotion have evolved considerably over time alongside increased  
44 internet and mobile device adoption<sup>9</sup> as well as new technologies. Early DHIs leveraging  
45 short-message service (SMS)<sup>10-15</sup> and digital media e.g. websites, video and CD-ROM<sup>10,16-18</sup>  
46 became widespread and were well-received by users. However, positive results were observed  
47 largely for sexual health knowledge and attitudes and less so for behaviours such as treatment  
48 adherence, human papilloma virus (HPV) vaccine uptake and condom use<sup>10,14,17,18</sup>. Moreover,  
49 intervention effectiveness tended to decline over time. Smartphones, in spite of their  
50 pervasiveness and functionalities, failed to gain positive responses from the community with  
51 regards to mobile phone applications intended to promote STI prevention and care<sup>19</sup>. The use  
52 of emerging technologies such as serious gaming, virtual reality and social media faced  
53 resulted in similar outcomes<sup>20-23</sup>, whereby little to no effects were observed for most sexual  
54 health behaviours with the exception of testing uptake. Ironically, while the motivation behind  
55 the dynamic adoption of technological innovations was likely *increased* user engagement,  
56 several authors have attributed the observed low intervention effectiveness to *reduced*  
57 immersion and flow i.e., feeling fully involved and focused on the activity<sup>24</sup>. This is

58 consistent with the notion that positive user engagement precedes positive interactions with  
59 intervention components, thereby leading to increased intervention efficacy<sup>25,26-29</sup>.

60 Continuing in the footsteps of adopting new technologies, there has been a recent shift towards  
61 conversational agents (CAs) for delivering DHIs across healthcare domains such as substance  
62 abuse, mental health, exercise and even stress-reduction<sup>30-35</sup>. For the purposes of this review,  
63 we adopt the definition of CAs as systems that can simulate conversation with users through  
64 natural language such as written text or voice thus permitting automated two-way  
65 communication between the user and system<sup>35,36</sup>. Examples of CAs range from the well-  
66 known open-domain virtual voice assistants such as Siri and Alexa<sup>37</sup> to customer service  
67 chatbots available through commercial websites and social media platforms such as Facebook  
68<sup>38</sup> and even embodied CAs which employ computer-generated avatars<sup>39</sup>. It has been suggested  
69 that DHIs allowing two-way interactions can increase intervention efficacy by addressing both  
70 non-intentional and intentional forms of non-adherence to target health behaviours<sup>40,41</sup>, and  
71 promoting user engagement by encouraging users to explore their attitudes and feelings in a  
72 more productive and personally relevant manner<sup>42,43</sup>. Furthermore, CAs particularly hold  
73 promise as a more innovative way to communicate with younger users<sup>44,45</sup> given their high  
74 digital literacy and familiarity with chat applications. Given the rate at which the field of  
75 natural language processing is advancing, CAs can also increase engagement by understanding  
76 the user and providing intelligent, relevant communication at all times to different target  
77 populations<sup>45</sup>.

78 In essence, it appears relevant to already examine the prospects that CA-based DHIs may offer  
79 for sexual health promotion. Furthermore, prior reviews on DHIs in this domain have  
80 primarily addressed effectiveness<sup>16-18,46-48</sup>, often with emphasis on randomized controlled  
81 trials<sup>10,46,47,49</sup> or peer-reviewed literature<sup>12</sup>. However, this approach may result in the exclusion  
82 of studies which could provide insight into the potential of CA-based interventions by

83 assessing user acceptability or reporting preliminary findings given the rapid advances in  
84 conversational technology. As the effectiveness and user acceptability of DHIs are  
85 inextricably linked, the aim of the present systematic review is to summarize available  
86 evidence regarding both the effectiveness and acceptability of conversational agents for sexual  
87 health promotion.

88

**Method****89 *Literature Search***

90 A systematic search of the literature was performed in October 2020 using PsycINFO, Web of  
91 Science, ACM Digital Library, IEEE Xplore, Medline, Embase and CMMC, not restricted by  
92 publication year or language. An updated search was performed in February 2021. Grey  
93 literature identified in those databases, including dissertations, theses, and conference  
94 proceedings, were also included for screening given the infancy of this field. Two sets of  
95 search terms were devised by the first reviewer (DB) and a librarian (SG) and customized for  
96 each selected database. The first set addressed conversational agents and included other  
97 related terms such as ‘chatbots’, ‘relational agent’, ‘virtual assistant’, ‘dialog system’ and  
98 ‘mHealth’. The second set addressed sexual health and included other related terms such as  
99 ‘HIV’, ‘sexually transmitted diseases’, ‘HPV’ and ‘syphilis’. The full search strategy can be  
100 found in the Supplementary Material. The protocol for this review was registered at the  
101 International Prospective Register of Systematic Review (PROSPERO; registration number  
102 CRD42021222969).

**103 *Inclusion and Exclusion Criteria***

104 Included studies had to meet three criteria: (i) described conversational agents or synonymous  
105 systems that permitted two-way interactions that were fully automated (i.e. without any human  
106 mediation)<sup>1</sup>, (ii) addressed any sexually-transmitted condition such as HIV/AIDS, HPV and  
107 other STIs or targeted aspects of sexual health promotion such as medication adherence and  
108 reducing risky sexual behaviour and (iii) described an evaluation applied to the technology,  
109 focusing on either health outcomes or end-user evaluations (e.g. acceptability, usability, or  
110 satisfaction, but not cost-effectiveness and cost-analysis outcomes). Forms of one-way

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<sup>1</sup> Also includes systems that may not intuitively be considered CAs, namely automated two-way text-messaging systems – they can be considered “old school” CAs that use SMS instead of chat applications.

111 communication, human-mediated communication and systems without response contingency  
112 (e.g. quizzes, ecological momentary assessment and computer-assisted self-interviewing) were  
113 excluded, as were studies which only evaluated the *idea* or *content* that will later be  
114 implemented, as the actual technology does not undergo evaluation. Reviews, meta-analyses,  
115 protocol papers and poster abstracts were excluded, as were citations with missing abstracts.  
116 No restriction was placed on study design given the varied and dynamic nature of the field.  
117 Screening procedures were piloted by the first and second reviewers (DB and LH). Once a  
118 sufficient kappa value<sup>50</sup> was achieved (>0.6, indicating substantial inter-rater agreement), the  
119 initial screening of articles was conducted independently based on the information contained  
120 in the title and abstract. Conflicts were discussed between DB and LH, and unresolved  
121 conflicts were discussed with a third reviewer (GJ). The same procedure was applied for full-  
122 text screening. After this, citation tracking was conducted to ensure that all relevant studies  
123 were identified, resulting in 31 included studies (Figure 1).

#### 124 ***Data Extraction and Synthesis***

125 Data extraction was conducted by DB and reviewed by GJ for completeness. The following  
126 data from the included studies were extracted: title, author, year, study design, sample size,  
127 target health behaviour, target population, interaction frequency, intervention duration,  
128 theoretical framework, technology platform and initiator and outcomes. Outcomes were  
129 classified as either health outcomes or user evaluations and were all summarized through a  
130 vote-counting strategy and are presented as a narrative synthesis of results. Health outcomes  
131 assessed in more than one study using a randomized controlled trial design were additionally  
132 analyzed through a meta-analysis. User evaluation outcomes, quantitative and qualitative,  
133 were organized around the components of a technology acceptance model (TAM), namely the  
134 DeLone and McLean Information Systems Success Model (D&M Model)<sup>51</sup> - *system quality*,  
135 *information quality*, *user satisfaction*, *actual use & intent to reuse* and *net benefits*.



136 *Meta-analysis*

137 Health outcomes assessed in more than one study using a randomized controlled trial design  
138 were additionally analyzed through a meta-analysis. For the meta-analysis, random effect  
139 models were used. Per included study, we calculated the effect size  $d$  and its standard error  
140 using suggested formulas for mean differences and odds ratio<sup>52</sup> in MacOS Numbers. For  
141 studies that had multiple outcome measures, an average effect size  $d$  and standard error was  
142 calculated using suggested formulas<sup>52</sup> and setting the multiple outcome correlation as  $r = .50$ .  
143 Heterogeneity was derived from the Q-statistic<sup>53</sup> and publication bias from funnel plots and  
144 Egger's test<sup>54</sup>. When publication bias was present, trim-and-fill analysis was conducted<sup>55</sup>. We  
145 conducted the meta-analysis for the five RCT studies including all outcomes, all objective  
146 outcomes, and all objective ART outcomes respectively (so excluding<sup>56</sup>) with the dmetar,  
147 meta, and metafor packages in RStudio (version 2021.09.1) for MacOS.

148

**Results**149 ***Overview of Studies***

150 Table 1 provides a summary of the included studies (n = 31). Thirteen RCTs were identified,  
151 and the remaining utilized either pre-post or post- study designs. Social Cognitive Theory was  
152 cited most often as the underlying theoretical framework<sup>57-63</sup>, followed by the Information-  
153 Motivation-Behavioral Skills model<sup>64-67</sup> and Motivational Interviewing<sup>68-70</sup>. Seventeen out of  
154 31 studies did not indicate an underlying theoretical framework.

155 The most common target health behaviour was antiretroviral therapy (ART) adherence  
156 (15/31). In contrast to ART, only four studies focused on preventive treatment i.e. pre-  
157 exposure prophylaxis (PrEP) and post-exposure prophylaxis (PEP) knowledge, uptake and/or  
158 treatment adherence<sup>56,71-73</sup>. Other studies addressed general sexual health and safe sex  
159 practices<sup>57,58,68,69,74</sup>, HIV/STI testing<sup>75,76</sup> and HIV risk factors such as heavy drinking<sup>68</sup> and  
160 medication adherence for bipolar disorder<sup>77</sup>. HPV vaccine attitude and uptake was the subject  
161 of three studies, targeting either mothers<sup>59,78</sup> or young adults<sup>79</sup>. Studies predominantly  
162 (24/31) took place in the United States. The populations of interest were broadly categorized  
163 as individuals at risk for HIV<sup>56-58,68,69,71,72,74,76,78-81</sup> and HIV-positive individuals who are  
164 initiating or taking ART, particularly those who have sub-par adherence<sup>60-62,64-67,70,73,77,82-86</sup>.  
165 Within these, groups which were targeted often were young people<sup>56,57,62,65,66,70,79,84</sup>, ethnic  
166 minorities<sup>58,65,66,74,80,81</sup>, sexual minorities<sup>65,66,68,71,73</sup>, women<sup>57,58,69,74,80,81</sup> and substance users  
167 <sup>64,68,73</sup>.

168 Mobile phone was the most common platform to deliver the interventions (22/31), which  
169 included short-message service (SMS)<sup>56-58,62-64,67,68,71,73,76,77,83-86</sup>, interactive voice response  
170 (IVR)<sup>60,61,82</sup>, instant messaging (IM)<sup>75</sup> and smartphone application (app)<sup>65,66</sup>. The remaining  
171 interventions were delivered via computer, either through websites<sup>59,69,74</sup> or desktop/tablet  
172 applications<sup>70,72,78-81</sup>. While all of the included systems permitted two-way interactions,

173 seventeen out of 31 studies allowed multi-turn interactions i.e., either the CA or user was able  
174 to respond more than once within the same conversation<sup>57,58,62,65-70,72,74,75,77-81</sup> and the  
175 remainder which were one-turn-only interactions<sup>56,59-61,63,64,71,73,76,82-86</sup>. Systems generally  
176 initiated interactions with users at fixed times e.g. daily<sup>58,60-64,73,76,77,82,84-86</sup>, twice a week<sup>57</sup>,  
177 thrice a week<sup>67,68</sup>, weekly<sup>56,60,71,83</sup> and monthly<sup>70</sup>. Some were user-initiated<sup>59,65,69,74</sup> while the  
178 rest were only used once to assess user acceptability outcomes.

179 Out of 31 studies, 26 looked at one or more user acceptability outcomes and 20 studies  
180 addressed intervention effectiveness through appropriate health outcomes.

### 181 *Effectiveness*

182 Out of 11 studies that assessed antiretroviral therapy outcomes, studies which used self-report  
183 measures<sup>62,65,70,77,82,84,86</sup> found support for intervention effectiveness whereas those employing  
184 pill count<sup>63-65,77,82,86</sup> and biomarker measures<sup>62,67,70,82-84</sup> did not support this. Pre-exposure  
185 prophylaxis outcomes were assessed in three studies also using self-report<sup>71</sup>, pill count<sup>71</sup> and  
186 biomarker measures<sup>56,73</sup>, all of which indicated significant effects. Positive findings were  
187 observed for multi-dimensional attitude towards HPV vaccine in two studies<sup>59,78</sup>, of which one  
188 found an additional near-significant effect for HPV vaccine uptake behaviour<sup>59</sup>. For condom  
189 use, two studies found no significant effects for condom use behaviour<sup>57,68</sup>, of which one  
190 found an improvement in condom use attitude but not intention<sup>68</sup>. One intervention was  
191 targeted at promoting a range of safe sex practices for women during pre-conception and was  
192 found to be effective for reducing the number of risks associated with (sexually transmitted)  
193 infectious diseases<sup>69</sup>.

194 *Meta-analysis*

195 The included RCTs looked at medication adherence for either antiretroviral therapy  
196 <sup>62,67,70,77</sup> or pre-exposure prophylaxis<sup>56</sup>. Table 2 summarizes the results for the conducted  
197 meta-analyses. For the five RCTs ( $n = 582$ ), there was a small and significant effect on  
198 medication adherence,  $d+ = 0.23$ , 95% CI [0.037; 0.4213],  $p = .030$ . favoring the chatbot  
199 intervention (Figure 2). This effect was not present after repeating the analysis for only  
200 objective outcomes ( $d+ = 0.19$ , 95% CI [-0.096; 0.484],  $p = .137$ ) (Figure 3), and with only  
201 ART studies ( $d+ = 0.10$ , 95% CI [-0.232; 0.424],  $p = .419$ ) (Figure 4). The funnel plots did not  
202 indicate publication bias (see Figures 5, 6 and 7).

203 *User Acceptability*

204 *System Quality*

205 Nine out of 26 studies evaluated *system quality*<sup>60,65,69,72,75,78,79,85,86</sup>. While ease of use  
206 was the most common measure (7/10), system quality was also evaluated through overall  
207 usability<sup>79</sup>, pragmatic quality<sup>72</sup> and response speed<sup>75,78</sup>. Users generally found the systems  
208 straightforward and easy to use. This was attributed to technological capabilities such as quick  
209 replies in instant messaging<sup>75</sup> and the general familiarity of mobile phone interfaces which  
210 ensured that the chatbot understood them. Interestingly, response speed was evaluated  
211 negatively in two studies, whereby users found it to be either unrealistically fast<sup>75</sup> or too slow  
212 and not efficient enough for a *machine*<sup>78</sup>.

213 *Information Quality*

214 *Information quality* was assessed in twelve out of 26 studies along content relevance  
215 <sup>58,66-69</sup>, content quantity<sup>58,66,85</sup>, clarity<sup>66,78,81</sup>, language style<sup>58,66,75</sup>, interaction intensity  
216 (depth, frequency and duration)<sup>58,61,62,68</sup> and repetitiveness<sup>67,78,85</sup>. While participants largely  
217 found the content relevant and useful for the target behaviour<sup>57,58,68,69</sup> (e.g. “these questions

218 are things that all girls think about...made me think about my behaviours<sup>57</sup>”), they voiced the  
219 desire for additional personalization of content<sup>67,68</sup>. Across three studies that assessed content  
220 quantity<sup>58,66,85</sup>, two reported that users wanted additional content on other health topics (e.g.  
221 side effects of ART<sup>66</sup>) and on non-health topics (e.g. communication and relationships<sup>58</sup>).  
222 Language style was evaluated in three studies, two of which found that language style should  
223 be more appropriate. For example, it is important to avoid sensitive phrases (e.g. using AIDS  
224 interchangeably with HIV) as well as graphic images portraying sickness<sup>66</sup>. For voice-based  
225 systems, users discouraged any harsh or judgmental intonation and wanted “straight talk” like  
226 from friend or relative<sup>58,66</sup>. Van Heerden and colleagues<sup>75</sup> instead found that users thought the  
227 language was too formal and incongruent with real life conversations. Qualitative feedback  
228 indicated that the clarity of some systems can be further improved by rewording and using  
229 visuals to complement the verbal and/or audio-visual dialogue<sup>66,78,81</sup>. Studies looking at  
230 repetitiveness<sup>67,78,85</sup> found that some users were irritated when the system did not exhibit the  
231 variety that is characteristic of natural conversations. Users expressed room for improvement  
232 regarding interaction intensity in four studies<sup>58,61,62,68</sup> – they wanted the conversations to  
233 occur more often i.e. daily or more and last longer<sup>58,61</sup> while others would have appreciated  
234 more or less messages sent to them depending on their preferences<sup>62,68</sup>.

### 235 *User Satisfaction*

236 Nine out of 26 studies assessed overall user satisfaction. Two studies<sup>68,70</sup> made use of  
237 the Client Satisfaction Questionnaire while others enquired about satisfaction<sup>59,62,64,85,86</sup> or  
238 acceptability<sup>57,81</sup> using one or more survey items. Across all studies, users reported above-  
239 average scores and that they found their experiences with the technology satisfying or  
240 enjoyable.

241

242            *Use*

243            *Intent to reuse* the system in the future was assessed in eight studies and most users  
244 (around 78% across studies) responded positively, expressing that they would like to continue  
245 receiving the intervention after the study or be open to using such a system in their daily lives.  
246 *Actual use* was assessed quantitatively in 10 studies through message response rate for SMS-  
247 based systems<sup>57,62,64,68,77,84,85</sup> and through usage metrics for smartphone applications and  
248 websites<sup>59,65,74</sup>. The average message response rate was around 69%, ranging from 47% to  
249 68% on the lower end<sup>84,85</sup> to 92% on the higher end<sup>68,77</sup>. Usage metrics indicated that an  
250 average of 88% participants accessed the systems<sup>59,65</sup> at least once and each interaction lasted  
251 around 10 minutes, and another system<sup>74</sup> received 4,390 topic-relevant messages with an  
252 average of three questions per session, indicating reasonable use of the system.

253            *Net Benefits*

254            Perceived net benefits were evaluated in more than half of the studies (14/26) through  
255 perceived usefulness<sup>56,57,60,61,64,68,71,75,78,80,84-86</sup> and the likelihood of recommending the system  
256 to other individuals<sup>56,57,62,64,65,67,81,84</sup>. Qualitative feedback from users indicated that the  
257 systems were useful for promoting a range of sexual health behaviours such as condom use  
258 (“these questions are things that all girls think about...”), HIV testing (“it could save time not  
259 having to wait at a clinic for a counsellor”) and HPV vaccine uptake (“...provided useful  
260 information and reinforced important points”). Some studies found that the systems targeting  
261 treatment adherence were only useful if users were facing difficulties with adequate adherence  
262<sup>61,71</sup>, consistent with the otherwise positive evaluations of perceived usefulness regarding  
263 systems targeting either individuals initiating treatment<sup>56,85</sup> or exhibiting poor adherence  
264<sup>62,64,85,86</sup>. Reminders were cited as being most useful feature by providing different strategies  
265<sup>68</sup>, minimizing forgetfulness when they were busy or at work<sup>61,84</sup> and that the reminders did  
266 not stop until they texted back<sup>86</sup>. Overall, users were also highly likely (86% across all

267 studies) to recommend the systems they used to others who are HIV-positive, to a friend, or to  
268 others in general.

### 269 *Additional User Acceptability Outcomes*

270 There were constructs identified in the set of user acceptability outcomes that did not  
271 fall under any component of the D&M Model and are therefore summarized below. Constructs  
272 associated with *privacy* and anonymity were assessed in five studies<sup>56,60,61,66,75</sup>, whereby a  
273 minority of users voiced a desire for additional measures (e.g. the ability to hide the  
274 application screen quickly, minimize attention from alerts and reminders) to avoid  
275 unintentional disclosure in three studies<sup>56,61,66</sup>. Two studies<sup>69,81</sup> assessed *trust* in the system  
276 and received positive feedback from users. Questions regarding general feelings of *comfort*  
277 and the lack of stigma were administered to users in five studies<sup>57,65,66,69,75</sup> out of which four  
278 revealed that users indeed felt safe and comfortable in their interactions with the system. One  
279 study<sup>65</sup> found that a small number of users faced instances of potential embarrassment and  
280 stigma when using the system in public and near their friends. In five studies, users were asked  
281 about the extent to which they felt *emotionally supported*, or cared for, by the system, all of  
282 which reported positive findings<sup>57,61,65,67,71</sup>. Out of the seven studies that looked at social  
283 presence, users expressed desire for increased *social presence* or actual human interaction in  
284 three studies<sup>58,78,80</sup> while the remainder, most of which utilized a static or embodied avatar,  
285 reported good or sufficient social presence<sup>66,75,81,85</sup>.

286

**Discussion**

287 Digital health interventions (DHIs) for sexual health promotion are becoming increasingly  
288 commonplace and are particularly attractive because at-risk groups are often unable to or are  
289 reluctant to seek out professional advice. In the spirit of adopting new technologies, DHIs  
290 using conversational agents (CAs) have begun to receive more attention for their added  
291 capacity to imitate natural interactions with humans. The CAs included in this review  
292 exhibited a marked variety in how the technology interacted with the users. Of interest were  
293 the relatively large number of CAs that allowed multi-turn interactions, which come across as  
294 more natural and are characterized by increased interactivity and feedback. These were  
295 particularly pronounced in the more recent years, likely explained by the rapid technological  
296 advances that have been made in the field of artificial intelligence<sup>87</sup>. Understandably, the  
297 included studies were largely pilot studies which indicated the infancy of this growing field  
298 but resulted in the lack of rigorous study designs utilizing appropriate control groups that  
299 would have aided in more empirical analysis. As the interest in CAs for sexual health is  
300 evidently rising, the present review situates itself well in summarizing the available evidence  
301 of their effectiveness and acceptability.

302 Most of the studies targeted medication adherence, either antiretroviral therapy (ART) or pre-  
303 exposure prophylaxis (PrEP), and meta-analytic findings supported the effectiveness of CA  
304 interventions for adherence when considering both self-report and objective measures as well  
305 as both medications. However, this result became non-significant upon excluding self-report  
306 measures and the single PrEP study, suggesting the need to consider how these systems can  
307 result in more tangible improvements for ART adherence. In general, CAs targeting ART  
308 adherence fall under the umbrella of *treatment*<sup>88</sup> and were able to help individuals who already  
309 have HIV to manage their symptoms through interactive reminders and information provision.  
310 In contrast, there were markedly fewer interventions addressing *prevention*<sup>88</sup> of sexual health-



311 related diseases, namely pre-exposure prophylaxis (PrEP), condom use, human papilloma  
312 virus (HPV) vaccine uptake and sexually-transmitted disease (STD) testing. Based on this  
313 limited number of studies, CA interventions resulted in positive outcomes for attitudes  
314 towards condom use and HPV vaccination uptake and testing behaviour. Given the difficulties  
315 in getting individuals to engage in precautionary behaviours<sup>89,90</sup>, additional studies are needed  
316 to explore how CAs can effectively support such behaviours.

317 Through the lens of the DeLone and McLean Information System Success Model<sup>51</sup>, the CA  
318 interventions were found to be acceptable to users in terms of ease of use, perceived  
319 usefulness, satisfaction and intent to reuse, which is likely to translate into actual use  
320 according to the D&M model<sup>91-93</sup> and other technology acceptance models<sup>94-97</sup>. In addition to  
321 reminders, CAs were seen as being capable of providing on-demand emotional support and  
322 useful information in an anonymous manner without human contact, consistent with proposed  
323 drivers of CAs for healthcare<sup>45</sup>. However, they were found to be lacking in aspects of  
324 information quality such that users desired additional, personalized, and clearer content  
325 communicated in an appropriate language style. While not included in traditional technology  
326 acceptance models as a separate construct, the heavy reliance on textual content and  
327 communication principles<sup>98</sup> in conversational systems lends to the importance of information  
328 quality, a point that is further supported by the number of included studies that evaluated this  
329 construct in some form.

330 The study identified an additional set of constructs that may play a role in user acceptability  
331 within this domain. *Trust* and *privacy* can be thought of as contemporary challenges that have  
332 permeated emerging technologies<sup>99-101</sup> and have been discussed in other extended TAM  
333 models within<sup>102,103</sup> and outside of healthcare<sup>104-106</sup>. Users both expected and were largely  
334 satisfied with the degree of privacy and trustworthiness exhibited by the systems, although the  
335 demand for security appears abundantly strong that additional features may be needed to

336 motivate long-term use. *Social presence* was found to be sufficient in only half of the studied  
337 systems, which could be attributed to the use of multimedia and embodiment through  
338 avatars<sup>43,107,108</sup>. An interesting issue arises in incorporating social presence into a system that is  
339 often touted for its capacity to enable anonymous, “non-human” and therefore self-disclosing  
340 interactions<sup>45,109–111</sup>, suggesting the need to achieve a delicate balance. While social presence  
341 has been implicated in the user acceptance of conversational agents in other areas<sup>38,108,112</sup>  
342 <sup>113,114</sup>, <sup>115,116</sup> <sup>117</sup>, its role in the sexual health domain remains to be disentangled. *Comfort* and  
343 *emotional support* have not received as much attention in the literature but these findings  
344 suggest that they may be important in specific domains such as domestic violence<sup>118,119</sup>, sexual  
345 issues<sup>120,121</sup> and mental health<sup>122</sup> where individuals need to feel safe and accepted while  
346 engaging with the system. While this review underscores the potential importance of these  
347 constructs, future studies can explore their role in user acceptance and inform their inclusion  
348 in extended TAM models for sexual health and related domains.

### 349 ***Conclusion***

350 Despite the limited body of evidence, these findings support the notion that CAs for sexual  
351 health may not only be effective but that users also find these useful and acceptable for a range  
352 of sexual health behaviours. While CAs are already capable of supporting antiretroviral  
353 therapy adherence through simple two-way interactions, more studies are required to  
354 understand how the potential of CAs can be leveraged for more complex behaviours. This  
355 review also emphasizes the value of rigorous, holistic, and mixed-method evaluations of CA-  
356 based DHIs to gain deeper insight into how the intervention components are perceived by  
357 users as a driver of intervention efficacy. To that end, the findings serve as a good starting  
358 point for how we might go about enhancing the user experience for these interventions and  
359 highlight the need for theoretical developments regarding technology acceptance models  
360 which are more applicable to sensitive domains. The question still remains for further research

361 as to whether and under what circumstances individuals would voluntarily adopt CAs outside  
362 the research context and in what way they can be reached in practice.

363

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367 ***Data Availability***

368 The authors confirm that the search strategy used in this study is available within the article  
369 and/or its supplementary materials. The data supporting this systematic review and meta-  
370 analysis are from previously reported studies and datasets, which have been cited. The  
371 processed data are available from the corresponding author upon request.

372 ***Conflict of Interest***

373 The authors declare no conflicts of interest.

374

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