# Effectiveness and acceptability of conversational agents for sexual health promotion: A systematic review and meta-analysis

Balaji, D.; He, L.; Giani, S.; Bosse, T.; Wiers, R.; de Bruijn, G.-J.

Link to publication

1      **Effectiveness and Acceptability of Conversational Agents for Sexual Health Promotion:**

2                          **A Systematic Review and Meta-Analysis**

3      Divyaa Balaji[1], Linwei He[2], Stefano Giani[3], Tibor Bosse[4], Reinout Wiers[5], Gert-Jan de Bruijn[6]

4      [1]Amsterdam School for Communication Research, University of Amsterdam, Amsterdam,

5      Netherlands

6      [2]Department of Communication and Cognition, Tilburg University, Tilburg, Netherlands

7      [3] University Library, University of Amsterdam, Amsterdam, Netherlands

8      [4]Behavioural Science Institute, Radboud University, Nijmegen, Netherlands

9      [5]Department of Psychology, University of Amsterdam, Amsterdam, Netherlands

10     [6] Department of Communication Science, University of Antwerp, Antwerp, Belgium

**Abstract**

Digital health interventions for sexual health promotion have evolved considerably alongside

innovations in technology. Despite these efforts, studies have shown that they do not

consistently result in the desired sexual health outcomes. This could be attributed to low levels

of user engagement, which can hinder intervention effectiveness as users do not engage with

the system enough to be exposed to the intervention components. It has been suggested that

conversational agents have the potential to overcome the limitations of prior systems and

promote user engagement through the increased interactivity offered by bidirectional, natural

language-based interactions. The present review therefore provides an overview of the

effectiveness and user acceptability of conversational agents for sexual health promotion. A

systematic search of seven databases provided 4,534 records and after screening, 31 articles

were included in this review. A narrative synthesis of results was conducted for effectiveness

and acceptability outcomes, with the former supplemented by a meta-analysis conducted on a

subset of studies. Findings provide preliminary support for the effectiveness of conversational

agents for promoting sexual health, particularly treatment adherence. These conversational

agents were found to be easy to use and useful, and importantly resulted in high levels of

satisfaction, use and intentions to reuse, while user evaluations regarding the quality of

information left room for improvement. The results can inform subsequent efforts to design

and evaluate these interventions, and offer insight into additional user experience constructs

identified outside of current technology acceptance models which can be incorporated into

future theoretical developments.

*Keywords*: sexual health, review, meta-analysis, HIV, chatbot, conversational agent, mHealth,

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[1]. 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 [2], ethnic minorities[3], sexual minorities[4], illicit

41        drug-users[5,6] and sex workers[7,8] 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[9] as well as new technologies. Early DHIs leveraging

45        short-message service (SMS) [10–15] and digital media e.g. websites, video and CD-ROM [10,16–18]

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[10,14,17,18]. 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[19]. The use

52        of emerging technologies such as serious gaming, virtual reality and social media faced

53        resulted in similar outcomes[20–23], 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 [24]. This is

58    consistent with the notion that positive user engagement precedes positive interactions with

59    intervention components, thereby leading to increased intervention efficacy [25,26–29].

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 [30–35]. 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 [35,36]. Examples of CAs range from the well-

66    known open-domain virtual voice assistants such as Siri and Alexa[37] to customer service

67    chatbots available through commercial websites and social media platforms such as Facebook

68    [38]and even embodied CAs which employ computer-generated avatars[39].  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[40,41], and

71    promoting user engagement  by encouraging users to explore their attitudes and feelings in a

72    more productive and personally relevant manner[42,43]. Furthermore, CAs particularly hold

73    promise as a more innovative way to communicate with younger users[44,45] 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[45].

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[16–18,46–48] , often with emphasis on randomized controlled

81    trials[10,46,47,49] or peer-reviewed literature[12]. 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)[1], (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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[1] 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[50] 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)[51] - *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 [52] 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[52] and setting the multiple outcome correlation as *r* = .50.

143    Heterogeneity was derived from the Q-statistic[53] and publication bias from funnel plots and

144    Egger's test[54]. When publication bias was present, trim-and-fill analysis was conducted [55]. 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[56]) 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 [57–63], followed by the Information-

153    Motivation-Behavioral Skills model [64–67] and Motivational Interviewing [68–70]. 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 [56,71–73]. Other studies addressed general sexual health and safe sex

159    practices [57,58,68,69,74], HIV/STI testing [75,76] and HIV risk factors such as heavy drinking [68] and

160    medication adherence for bipolar disorder [77]. HPV vaccine attitude and uptake was the subject

161    of three studies, targeting either mothers [59,78] or young adults [79]. 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 [56–58,68,69,71,72,74,76,78–81] and HIV-positive individuals who are

164    initiating or taking ART, particularly those who have sub-par adherence [60–62,64–67,70,73,77,82–86].

165    Within these, groups which were targeted often were young people [56,57,62,65,66,70,79,84], ethnic

166    minorities [58,65,66,74,80,81], sexual minorities[65,66,68,71,73], women [57,58,69,74,80,81] and substance users

167    [64,68,73].

168    Mobile phone was the most common platform to deliver the interventions (22/31), which

169    included short-message service (SMS)[56–58,62–64,67,68,71,73,76,77,83–86], interactive voice response

170    (IVR)[60,61,82], instant messaging (IM)[75] and smartphone application (app)[65,66]. The remaining

171    interventions were delivered via computer, either through websites[59,69,74] or desktop/tablet

172    applications[70,72,78–81]. 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[57,58,62,65–70,72,74,75,77–81] and the

175    remainder which were one-turn-only interactions [56,59–61,63,64,71,73,76,82–86]. Systems generally

176    initiated interactions with users at fixed times e.g. daily [58,60–64,73,76,77,82,84–86], twice a week [57],

177    thrice a week [67,68], weekly [56,60,71,83] and monthly [70]. Some were user-initiated [59,65,69,74] 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[62,65,70,77,82,84,86] found support for intervention effectiveness whereas those employing

184    pill count[63–65,77,82,86] and biomarker measures[62,67,70,82–84] did not support this. Pre-exposure

185    prophylaxis outcomes were assessed in three studies also using self-report[71], pill count[71] and

186    biomarker measures[56,73], all of which indicated significant effects. Positive findings were

187    observed for multi-dimensional attitude towards HPV vaccine in two studies[59,78], of which one

188    found an additional near-significant effect for HPV vaccine uptake behaviour[59]. For condom

189    use, two studies found no significant effects for condom use behaviour [57,68], of which one

190    found an improvement in condom use attitude but not intention[68]. 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 [69].

194        *Meta-analysis*

195        The included RCTs looked at medication adherence for either antiretroviral therapy

196   [62,67,70,77] or pre-exposure prophylaxis[56]. 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* [60,65,69,72,75,78,79,85,86]. While ease of use

206   was the most common measure (7/10), system quality was also evaluated through overall

207   usability [79], pragmatic quality [72] and response speed [75,78]. 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 [75] 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 [75] or too slow

212   and not efficient enough for a *machine* [78].

213        *Information Quality*

214        *Information quality* was assessed in twelve out of 26 studies along content relevance

215   [58,66–69], content quantity [58,66,85], clarity [66,78,81], language style [58,66,75], interaction intensity

216   (depth, frequency and duration) [58,61,62,68] and repetitiveness [67,78,85]. While participants largely

217   found the content relevant and useful for the target behaviour [57,58,68,69] (e.g. "these questions

218  are things that all girls think about…made me think about my behaviours[57]”), they voiced the

219  desire for additional personalization of content[67,68]. Across three studies that assessed content

220  quantity [58,66,85], two reported that users wanted additional content on other health topics (e.g.

221  side effects of ART [66]) and on non-health topics (e.g. communication and relationships [58]).

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[66]. For voice-based

225  systems, users discouraged any harsh or judgmental intonation and  wanted "straight talk" like

226  from friend or relative[58,66]. Van Heerden and colleagues [75] 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 [66,78,81]. Studies looking at

230  repetitiveness [67,78,85] 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 [58,61,62,68] – they wanted the conversations to

233  occur more often i.e. daily or more and last longer [58,61] while others would have appreciated

234  more or less messages sent to them depending on their preferences [62,68].

235      *User Satisfaction*

236      Nine out of 26 studies assessed overall user satisfaction. Two studies [68,70] made use of

237  the Client Satisfaction Questionnaire while others enquired about satisfaction [59,62,64,85,86] or

238  acceptability [57,81] 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 [57,62,64,68,77,84,85] and through usage metrics for smartphone applications and

248    websites [59,65,74]. The average message response rate was around 69%, ranging from 47% to

249    68% on the lower end [84,85] to 92% on the higher end [68,77]. Usage metrics indicated that an

250    average of 88% participants accessed the systems[59,65] at least once and each interaction lasted

251    around 10 minutes, and another system[74] 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 [56,57,60,61,64,68,71,75,78,80,84–86] and the likelihood of recommending the system

256    to other individuals [56,57,62,64,65,67,81,84]. 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    [61,71], consistent with the otherwise positive evaluations of perceived usefulness regarding

263    systems targeting either individuals initiating treatment [56,85] or exhibiting poor adherence

264    [62,64,85,86]. Reminders were cited as being most useful feature by providing different strategies

265    [68], minimizing forgetfulness when they were busy or at work [61,84] and that the reminders did

266    not stop until they texted back [86]. 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[56,60,61,66,75], 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 [56,61,66]. Two studies[69,81] 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[57,65,66,69,75] out of which four

278  revealed that users indeed felt safe and comfortable in their interactions with the system. One

279  study [65] 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[57,61,65,67,71]. 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 [58,78,80] while the remainder, most of which utilized a static or embodied avatar,

285  reported good or sufficient social presence [66,75,81,85].

**Discussion**

286

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[87]. 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*[88] 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*[88] 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[89,90], 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[51], 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 [91–93] and other technology acceptance models[94–97]. 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[45]. 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[98] 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 [99–101] and have been discussed in other extended TAM

333    models within[102,103] and outside of healthcare [104–106]. 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[43,107,108]. 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[45,109–111], 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 [38,108,112]

342    [113,114], [115,116] [117], 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[118,119], sexual

345    issues[120,121] and mental health[122] 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                                      **Declarations**

364      *Funding*

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366      [grant number 406.D1.19.054].

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.

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