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Comparison of short messaging service self-reported adherence with other adherence measures in a demonstration project of HIV preexposure prophylaxis in Kenya and Uganda

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Abstract

Objective: Short messaging service (SMS) can collect adherence data on a frequent basis and is relatively anonymous, and therefore could potentially reduce recall and social desirability biases prevalent in other self-reported measures.

Methods: We compared SMS self-reported adherence with three self-reported adherence questions (rating of ability to adhere, frequency of doses taken, percentage of doses taken) and two objective adherence measures [electronic adherence monitoring (EAM) and plasma tenofovir levels] using data from HIV-uninfected members of serodiscordant couples enrolled in a preexposure prophylaxis demonstration project in Kenya and Uganda.

Results: Of 373 enrolled participants, 256 (69%) were male and median age at enrolment was 29 years (26, 35). Fifty-two percent were from Kenya and median education at enrolment was 10 years (7,12). Overall, median adherence was 90, 75, 85,94 and 79%, respectively, for self-report by SMS, rating, frequency, percentage and EAM adherence. Spearman's correlation coefficient between SMS and interviewer- administered self-reported measures was 0.18 for rating and frequency, 0.22 for percentage and 0.14 for EAM (all $P < 0.001$). The estimated difference in average adherence between SMS and self-reported rating, frequency, percentage adherence and EAM was 8.1 ($P < 0.001$), 0.3 ($P = 0.81$), −5.2 ($P < 0.001$) and 9.5 ($P < 0.001$), respectively. Area

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Conflicts of interest

All authors have no conflict of interest.

under the receiver-operating curve assessing the ability of SMS self-report to discriminate between detectable and undetectable tenofovir was 0.51.

Conclusion: Our study found low correlation between SMS self-report and other self-reported and objective adherence measures and did not discriminate between detectable and undetectable plasma tenofovir levels. Future use of SMS self-report should explore alternative means for reducing potential biases.

Keywords

adherence; HIV preexposure prophylaxis; Kenya; self-reported adherence; short messaging service; Uganda

Introduction

Of the 1.8 million global new HIV infections in 2015, about 64% occurred in sub-Saharan Africa [1]. Importantly, clinical trials examining efficacy of preexposure prophylaxis (PrEP) have indicated that PrEP can prevent transmission of HIV by over 90% if PrEP is taken consistently [2,3]. To minimize future HIV infections, it is important that we understand PrEP adherence using novel and practical measures, particularly for individuals in sub-Saharan Africa.

Measurement of adherence is challenging. Adherence measures consist of subjective self-report, as well as objective measures, including announced and unannounced pill counts, pharmacy refills, drug levels (e.g. in plasma, dried blood spots [2] and hair) and electronic monitoring. Each of these measures has advantages and limitations, and none may be considered as a gold standard. Self-report is inexpensive and simple to administer, but is often considered an overestimate compared with objective measures owing to recall and social desirability bias [4]. Pill counts are also simple and inexpensive, yet they are also susceptible to social desirability bias, especially when announced, as individuals may remove pills to appear more adherent than they were. Drug levels provide evidence of ingestion but are expensive and may vary considerably among and within individuals [5]. Electronic monitoring measures adherence on a dose-by-dose basis; however, it is also expensive and subject to social desirability bias (i.e. opening the device without taking pills) and nonuse [4]. Novel approaches to measurement of adherence are therefore needed.

SMS (short messaging services), or text messaging, is an extremely common technology that could be used to obtain self-reported adherence. Indeed, approximately 82% of Kenyans and 65% of Ugandans own a mobile phone [6]. Importantly, SMS can collect data on a frequent basis, thus potentially reducing recall bias. SMS could also potentially minimize social desirability biases because of the relative anonymity of this method compared with face-to-face interaction with clinic or study staff. In this analysis, our objective is to compare SMS self-reported adherence to interviewer-administered self-reported adherence, electronic adherence monitoring (EAM) and tenofovir plasma drug levels in a demonstration project of PrEP conducted among HIV serodiscordant couples in Kenya and Uganda.

Materials and methods

The partners demonstration project

The Partners Demonstration Project was a prospective, open-label study of integrated antiretroviral therapy (ART) and PrEP delivery for HIV prevention among high-risk heterosexual HIV serodiscordant couples in Kenya and Uganda. Study procedures are detailed elsewhere [7]. In brief, eligible couples were at least 18 years of age, sexually active and intending to remain as a couple for at least 1 year. The HIV-uninfected partner was offered once daily oral PrEP (emtricitabine 200 mg/tenofovir disoproxil fumarate 300 mg) free of charge with use recommended until the partner living with HIV had been on ART for at least 6 months, permitting time to achieve viral suppression. Couples were followed at Month 1 and then quarterly for up to 2 years. At the end of study follow-up, 8.6% of study participant partners on ART had unsuppressed or unknown viral load levels. Likewise, the study reported a low infection rate with four incident seroconversions after enrolment. None of the conversions exhibited resistance to study drug [8].

Adherence was assessed in several ways. First, follow-up visits included interview administered self-reported adherence questions with the following three assessments, each referring to the prior 28 days:

(1) Self-reported rating: ‘Please tell me your ability to take study pill’ (responses categorized as very poor, poor, fair, good, very good or excellent);

(2) Self-reported frequency: ‘Did you take your study tablets all the time?’ (responses categorized as none of the time, a little of the time, some of the time, a good bit of the time, most of the time or all of the time); and

(3) Self-reported percentage: ‘What percentage of the time were you able to take the study tablets exactly as directed?’ (categorized in 10% increments, ranging from 0 to 100%).

In addition, EAM data were collected continuously during PrEP use with the Medication Event Monitoring System (MEMS; WestRock, Switzerland) and downloaded at each study visit. Dried blood spots were prepared for plasma tenofovir levels at each study visit and assessed from a randomly selected 15% subset of HIV-1 uninfected partners. Detection of tenofovir in plasma was measured via ultraperformance liquid chromatographic-tandem mass spectrometric (LC-MS/MS), with a limit of quantification of 0.31 ng/ml [2].

The partners mobile adherence to preexposure prophylaxis study

The Partners Mobile Adherence to PrEP (PMAP) substudy was designed to assess PrEP adherence and concurrent risk for HIV acquisition via SMS surveys and was implemented at two study sites (Thika, Kenya and Kampala, Uganda). HIV-negative partners were eligible if they had at least 3 months of planned PrEP use, owned a mobile phone using a service provider compatible with the SMS platform (i.e. Safaricom in Thika; MTN and Airtel in Kampala), were literate, able to receive and send an SMS, and had regular access to electricity for charging their phone. Eligible participants completed a 1-week trial period of

daily surveys and were enrolled if they completed at least three daily surveys; additional training was provided as needed.

In the Partners Demonstration Project, participants were sent daily SMS surveys for 14 days, 7 days before and 7 days after each scheduled study visit. Surveys were sent at participant-selected times in the participant's preferred language (English, Swahili, Kikuyu or Luganda) and were available for responses for 23 h after delivery. Each survey was initiated only after receipt of a four-digit password and consisted of seven questions with branching logic on sexual activity and PrEP adherence in the prior 24 h. Specifically for adherence, participants were asked about their prior pill intake in the interview question, 'Did you take your study drug since this time yesterday? Enter 1 for 'yes' and 0 for 'no'. Participants were incentivized with approximately $0.50 worth of airtime for each completed survey, which was automatically sent to their phones. SMS surveys were sent, while participants were eligible to take PrEP and withheld during protocol-defined holds (e.g. drug toxicity). During cellular network outages lasting more than 1 day, additional SMS surveys were sent to affected participants so approximately 14 surveys were sent around each study visit.

Statistical analysis

Participant characteristics were summarized using frequencies, means or medians, respectively, for categorical and continuous variables. Site characteristics were compared using Fisher's exact test for proportions, the Student's t-test for normally distributed data and the Wilcoxon rank sum test for nonnormally distributed data.

As has been previously done [4,9], self-reported rating and self-reported frequency response categories were assigned quantitative adherence values in 20% increments. For example, the lowest category (e.g. 'very poor' for self-reported rating) was assigned 0% and the highest category (e.g. 'all of the time' for self-reported frequency) was assigned 100%. We also assessed the plausibility of this assignment using graphs of average tenofovir levels by categories of self-report. These graphs showed a linear increase in tenofovir levels from the lowest to the highest categories of the self-report measures, thus supporting this approach to analysis (see Supplemental figure 3, http://links.lww.com/QAD/B328).

EAM was calculated as the number of openings divided by the number of expected openings during the total number of days for which PrEP had been dispensed and a drug hold was not in effect in the month prior to each participant-visit. Openings by study staff were not counted (e.g. openings only to switch medication bottles). Participant-visits were excluded if the participant missed the visit, had missing adherence data (e.g. a broken or lost device), protocol-defined PrEP holds (e.g. due to an adverse event) or had adherence more than 120%, likely reflecting device error or unexpected device use (e.g. opening the pill bottle multiple times without removing a dose).

To compare SMS self-report to other adherence measures, we first aligned the time periods of each measure to the extent possible by participant. Specifically, to align SMS self-report to interviewer-administered self-reported adherence, we identified all SMS self-reports occurring within the 28 days prior to the interviewer-administered self-report. To align SMS self-report and EAM, we identified all device opening(s) corresponding to the respective

SMS self-report. Lastly to align SMS self-report with tenofovir levels, we identified all SMS self-reports in the 7 days preceding sample draw date; tenofovir levels have been shown to reflect dosing in the past 7 days [5]. Once the time periods were aligned, each method was compared with SMS self-report within participant such that each participant was their own control. To avoid undue influence from outlying values, average SMS self-report adherence computed from less than three SMS surveys was censored.

Statistical comparisons of SMS self-report versus interviewer-administered self-report and versus EAM were performed in three ways. First, we computed the Spearman correlation coefficient. We then tested the hypothesis that there were no within-participant differences, using a population-averaged fixed-effects model assuming an exchangeable correlation structure to account for within participant dependence. Finally, we fit Bland–Altman plots comparing SMS self-report against each self-reported measure and against EAM to visually assess the direction of bias. In a sensitivity analysis, we reran the Spearman's correlation and retest the hypothesis of within-participant differences considering EAM adjusted for reported pocket dosing.

To compare SMS self-report against detectable plasma tenofovir, we utilized the area under the receiver-operating curve (AUROC), computed from logistic regressions of SMS self-reported adherence against detectable tenofovir levels (≥0.31 ng/ml). We further explored the threshold consistent with daily dosing (>40 ng/ml) in a sensitivity analysis.

The potential for 'white coat' adherence (i.e. behaviour influenced by the timing of the study visit) was assessed by the comparison of adherence around the study visit (study visit ±7 days) to that between visits (8–21 days from study visit) as well as comparing adherence before the study visit (−7 days) to that after (+7 days) using the signrank test. This test was performed in both EAM and SMS self-report.

To assess comparability of the objective measures, we also computed the AUROC for EAM adherence against detectable tenofovir levels.

Analyses comparing SMS-self report to other measures were performed on the combined dataset (Thika and Kampala) and then stratified by site. All statistical analyses were performed using Stata 13 (StataCorp, College Station, Texas, USA).

Ethics statement

Ethical approval was obtained from the institutional review boards at Kenya Medical Research Institute, Uganda National Council for Science and Technology, Partners Healthcare/Massachusetts General Hospital and the University of Washington. All participants provided written informed consent.

Results

Overall participant characteristics

Of the 373 participants enrolled in the PMAP substudy, 256 (69%) were men and median age at enrolment was 29 years (26–35). The median educational attainment at screening was 10 years (7–12).

Comparison of short messaging service to other adherence measures

In each of the following sections, we describe the datasets used in the comparison, present the respective summary adherence values and then provide the results from the comparison.

SMS and interviewer-administered self-report

A total of 8118 SMS self-report surveys from 315 participants aligned to 1103 interviewer-administered self-reports. There was a median (IQR) of three (2–5) self-reported interviews per participant, each of which aligned to a median [interquartile range (IQR)] of seven (6–8) SMS surveys. The median (IQR) adherence among aligned records was 93% (83–100%), 80% (70–88%), 88% (80–95%) and 100% (93–100%), respectively, for self-report by SMS, rating, frequency and percentage adherence. Spearman's correlation coefficient between SMS and interviewer-administered self-reported measures was 0.18 for self-reported rating and self-reported frequency and 0.22 for self-reported percentage (all $P < 0.001$, Table 1). The estimated difference between SMS self-report and self-reported rating, frequency and percentage adherence was 8.1 [95% confidence interval (95% CI): 5.6–10.6; $P < 0.001$], 0.3 (95%. CI: 2.2–2.8; $P = 0.81$) and −5.2 (95%. CI: −7.7, 8, −2.6; $P < 0.001$), respectively (Table 2).

Short messaging service self-report and electronic adherence monitoring

A total of 13 452 EAM records from 322 participants had an SMS survey on the same day, with a median of 37 (20–58) SMS surveys per participant. The median (IQR) SMS self-reported and EAM adherence were 93% (83–98) and 84% (61–96), respectively with an estimated difference of 9.5% (95% CI: 5.8–13.1; $P < 0.001$) Spearman's correlation between the two measures was 0.14. Considering EAM with adjustment for pocket doses, the estimated difference was 2.2% (95% CI: −1.2 to 5.7; $P = 0.21$) and Spearman's correlation was 0.15.

Short messaging service self-report and detectable plasma tenofovir

A total of 1154 SMS surveys aligned to 175 tenofovir levels, a median (IQR) of 7 (6–8) SMS surveys per participant. Among the aligned records, the median (IQR) SMS adherence was 100% (83–100) (Table 3) and 158 (90%) of the samples had detectable tenofovir levels. The AUROC comparing the two measures was 0.51 (Fig. 1) [10]. Results from the sensitivity analysis exploring the threshold consistent with daily dosing were similar, with the maximum discrepancy of 0.05 (5%) observed from the comparison against SMS self-report and that against self-reported frequency (Supplemental Figure 4, http://links.lww.com/QAD/B328).

Bias assessment and comparison of objective measures

Adherence was left skewed (i.e. high) as reflected by the concentration of data points to the right of the Bland–Altman plots (Fig. 2) [11]. SMS self-report was higher than self-reported rating and EAM (as shown by the concentration of points above the line of equivalence), lower than self-reported percentage but similar to self-reported frequency (Fig. 2). In addition, the median (IQR) EAM adherence within 7 days of the study visit was 82% (58–94), while that between the visits (7–21 days from study visit) was 78% (45–93), $P < 0.001$. Similarly, the median (IQR) EAM adherence in the 7 days prior to the study visit was 76% (49–95) and that in the 7 days following the visit 90% (71–100), $P < 0.001$. For SMS self-report, the median (IQR) adherence within 7 days of the study visit was 92 (79–98) and that between study visits, 100 (75–100), $P = 0.68$. Likewise, median (IQR) SMS adherence in the 7 days prior was 94 (81–100), while that in the 7 days after the study visit was 93 (77–100), $P = 0.99$.

In the analysis assessing the two objective adherence measures, the AUROC comparing EAM and undetectable tenofovir was 0.78 (95% CI 0.67–0.89) and 0.87 (95% CI 0.78–0.96), respectively, for EAM adjusted and unadjusted for pocket dosing.

The AUROC assessing discrimination of detectable tenofovir levels was 0.66, 0.68 and 0.73, respectively, for self-reported rating, frequency and percentage adherence (Fig. 1).

Comparisons by site

One hundred and ninety-three (52%) participants were from Thika and 180 (48%) were from Kampala. The percentage of male participants was higher in Thika than Kampala (80 versus 56%, $P < 0.001$) and participants were slightly older in the Thika site [median age (IQR); 30 (27–36) versus 28 (24–34), $P = 0.01$]. The median (IQR) years of educational attainment at screening was 10 (8–12) at Thika and 9.5 (7–13) at Kampala ($P = 0.07$).

Overall and in the aligned datasets, adherence was higher among participants in Thika than in Kampala for self-reported adherence by SMS, rating and frequency. Similarly, EAM was higher at Thika overall. The rest of the differences were not statistically significant (Supplemental Table 1, http://links.lww.com/QAD/B328).

Discussion

In this analysis, adherence was high (median >80%) by most measures, but somewhat lower by self-reported rating and electronic monitoring; these findings are similar to the overall adherence reported in the Partners Demonstration Project [7]. In comparisons of SMS self-report against other adherence measures, we found weak agreement, with the highest correlation coefficient of $r = 0.22$ for SMS self-report against self-reported percentage adherence. Correlation between EAM and SMS self-report remained poor even when adjusting for reported pocket doses. Similarly, SMS self-report did not discriminate between detectable and undetectable tenofovir (AUROC 0.51). Electronic monitoring adherence, however, discriminated well between detectable and undetectable tenofovir (AUROC 0.87), suggesting validity in our objective measures. Our study thus finds that self-report by SMS did not perform well overall in this context.

We hypothesized that SMS self-report would perform better than interviewer-administered self-report, in part, due to a short recall period (i.e. 24 h). However, despite the short recall, SMS self-report actually had lower correlation with EAM and lower ability to discriminate between detectable and undetectable tenofovir levels than other self-reported adherence. Inaccurate recounting of pill taking may be due to the regularity of the activity, a phenomenon elaborated by a psychology study on how the concepts of regularity and similarity of behaviour affect cognitive processes [12]. In that study, business students were asked about 12 behaviours on a spectrum of regularity (regular to irregular) and similarity (similar to dissimilar), including behaviours such as brushing teeth, washing hair, going out in the evening, having dinner and snacking. When recounting regular activities, participants were likely to use estimation rather than enumeration methods, which may result in inaccuracy in a short recall period.

Other studies have found higher correlations between self-report and objective adherence measures over relatively longer time periods, suggesting that accuracy of estimation may increase when considering regular behaviours over time. In one study comparing 3-day, 7-day and 1-month self-reports against electronic monitoring, over-reporting (self-report minus EAM) of adherence was significantly higher for shorter recall periods than 1-month recall periods [9]. Another study of 78 highly adherent ART patients in London reported a higher correlation with electronic monitoring for a 2-week compared with a 3-day recall period [13]. Similarly, a meta-analysis concluded that longer recall periods were more likely than shorter ones to be significantly correlated with viral load, although the relationship was not statistically significant [14].

Another potential explanation for the poor performance of SMS self-report may be persistent social desirability bias despite the relative anonymity of SMS-based reporting. To explain social desirability bias, two potential cognitive processes have been proposed [15]: intentional deception and misremembering. The former is a conscious process that occurs when there is a perceived negative consequence of admitting nonadherence, while the latter uses the concept of ‘source monitoring’, which assumes that it is not always possible to separate intention from action. That if a patient decides to take medication, intends to be adherent, but forgets to take the medication, they may misremember their intention as the actual act of taking the dose and report it as such. Of note, SMS-self reported adherence around the study visit was not different from that between study visits and neither was SMS-self report adherence before different from that after the study visit. We therefore do not see evidence of ‘white-coat’ adherence, yet overall social desirability bias unrelated to the timing of the study visit may still have been present. In addition, although EAM adherence around the study visit (±7 days) was significantly higher than that between the study visits, EAM adherence in the 7 days before the study visit was significantly lower than that 7 days after, suggesting perhaps a counselling effect from the sessions conducted at the study visit.

Interestingly, although correlation between average SMS self-report and other self-reported measures (e.g. percentage, frequency and rating) was low, average adherence was similar across most measures. As shown by the different biases in the Bland–Altman plots, reporting by these adherences was not uniform. Each measure may have involved estimation and enumeration in varying degrees and could have been affected differently by recall and social

desirability biases. The similarity of adherence in such instances might be explained by the concept of ‘regression to the mean’ whereby the measures were likely not to concur on a given occasion but because they both were assessing the same thing – adherence – in the end, the averages tended to converge to a common value.

Adherence was generally higher among participants in Thika than those in Kampala. Of note, Thika had a relatively higher proportion of men than Kampala, and in a separate study also conducted with PMAP participants that assessed the acceptability of SMS surveys as a research data collection tool, women were more likely than men to report challenges with the SMS surveys [16]. The lower adherence at Kampala therefore may be due to a misclassification bias arising among women having challenges with the SMS surveys. In addition, participants in Thika were generally older and somewhat more educated. Several studies have shown a positive correlation between adherence and both age [17,18] and education [18,19].

Self-reported items performed relatively better than SMS self-report (Table 1, Fig. 1). Although self-reported measures usually appear to be overestimates of adherence compared with the objective measures of EAM and tenofovir levels, self-reported measures are accessible and relatively inexpensive to administer. Of the three self-reported items, self-reported rating had the lowest instances of participants reporting 100% (Supplemental Figure 3, http://links.lww.com/QAD/B328) and thereby was more likely than others to identify individuals with challenges. Alternatively, pharmacy refill can be a practical approach to adherence monitoring in routine care, as a missed refill should trigger follow-up. Importantly, with any adherence measure, programmes should build in automated follow-up (e.g. through a community health worker or counsellor) to help optimize PrEP adherence [20].

This study has some limitations. First, the amount of data are limited in some comparisons. Specifically, for the comparison of SMS self-report against interviewer-administered self-report, an average of 7 days of SMS aligned to standard self-reported adherence, yet interviewer administered self-report references 28 days. However, for the comparison against objective measures, SMS aligned with EAM per day with an average of 48 matches per participant. Likewise, SMS self-report aligned fittingly with tenofovir levels with an average 7 seven days of SMS aligning to each tenofovir level. Tenofovir levels have been shown to be consistent with dosing in the past 7 days [21] and therefore this comparison too was fair. Second, generalizability of our findings is limited. This study was conducted on the HIV-negative partner from a serodiscordant couple who were aware of their partner’s status, willing and able to respond to SMS messages. It was conducted at two relatively low risk sites in East Africa, both offering free PrEP. Results therefore may be generalizable to similar settings only. Third, this study focused on all study participants without regard to risk level, yet in a prior analysis we found that individuals at a ‘high’ risk of infection adhere and may behave differently to those at ‘low’ or ‘very low’ risk levels [22]. Future studies may compare SMS self-report to other measures stratifying by risk level. Another limitation is the potential of biases such as social desirability – although not supported by our data – which are endemic to face-to-face interviews. Last but not least, EAM and tenofovir levels could potentially have been manipulated as has been previously seen in similar settings [23].

However, the high concordance between the two objective measures (EAM and detectable plasma tenofovir) is suggestive of high-quality measurement and manipulation if any was likely low.

In sum, our study found that SMS self-report had low correlation with other adherence measures and did not discriminate between detectable and undetectable plasma tenofovir levels. Future SMS self-report studies could explore some alternative approaches. For instance, a preamble acknowledging the difficulty of high and consistent adherence (e.g. wording the questions in such a way that nonadherence is expected and accepted) may mitigate any prevalent social desirability bias [12]. Likewise, the use of interview methods such as audio computer assisted interviews (ACASI) may reduce the potential of this bias [24]. Future studies might also consider SMS self-report referencing longer periods of time; such periods are more suited for estimation, which is common in recounting regular activities such as pill taking [12]. In addition, when PrEP becomes available and affordable in routine clinical care, particularly in low resource settings, social desirability bias may reduce. Ongoing studies of multiple adherence measures in this context will therefore be needed. SMS surveys may still be valuable for understanding behaviours related to adherence, such as sexual behaviour and risk for HIV transmission, but further studies are needed to understand the extent of any prevalent biases.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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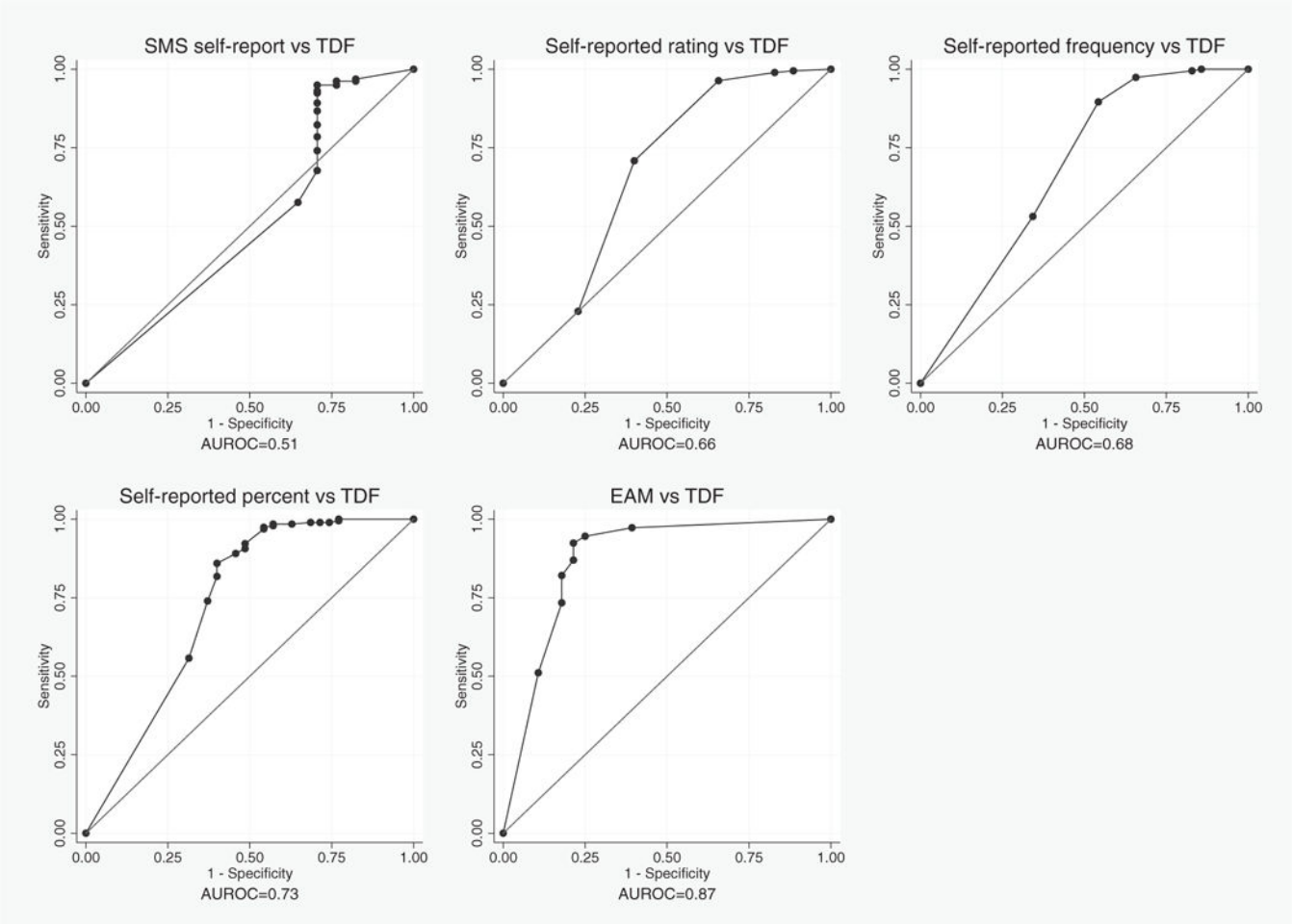

Fig. 1. Comparison of short messaging service, self-report and electronic adherence monitoring versus detectable plasma tenofovir.

An area under the receiver-operating curve (AUROC) of 0.5 lies on the diagonal line and implies that discrimination was no better than random chance. AUROC over 0.8 is considered good [10].

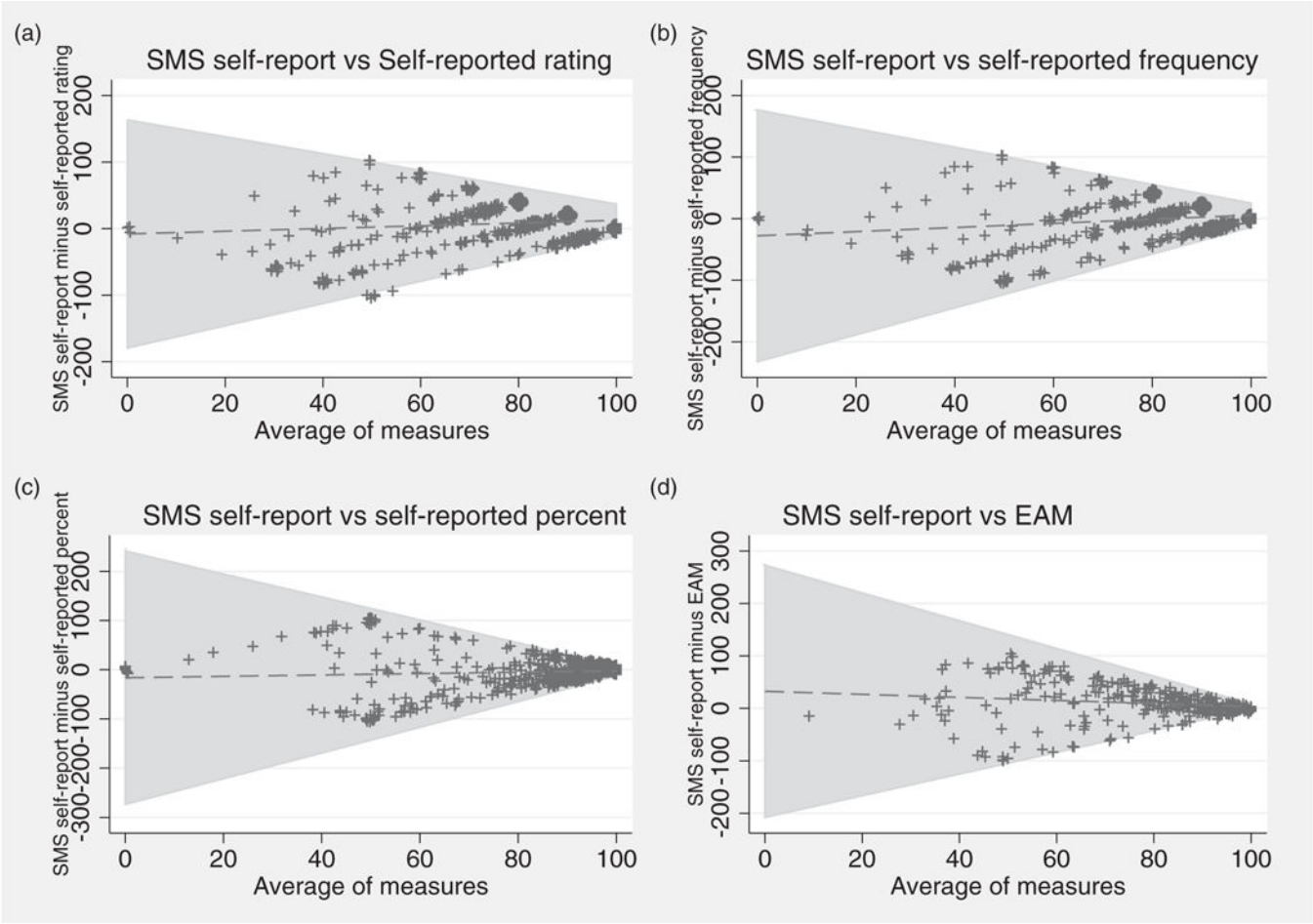

Fig. 2. Pairwise agreement between measures.

Each Bland–Altman plot indicates the difference between the two measures on the vertical axis against the mean of the same measures on the horizontal axis [11]. Data points above the line of equivalence indicate that SMS self-report was higher than the comparator and *vice versa.* On the horizontal axis, data points to the right indicate high adherence and data points to the left low adherence from both measures.

Table 1.

Correlation among adherence measures using Spearman's correlation coefficient.

	SMS self-report	Self-reported rating	Self-reported frequency	Self-reported percentage	EAM
SMS self-report					
Self-reported rating	0.18				
Self-reported frequency	0.18	0.66			
Self-reported percentage	0.22	0.63	0.64		
EAM	0.14	0.47	0.53	0.61	

A correlation of 1.0 is a perfect positive correlation, meaning that the two measures move upward or downward together to the same degree, while a correlation of −1.0 means that the two measures move in opposite directions to the same degree. The closer the correlation is to 1.0 or −1.0, the stronger the relation between the two measures being compared. $P < 0.05$ for all comparisons. EAM, electronic adherence monitoring; SMS, short messaging service.

Table 2.

Unadjusted paired comparison using fixed effects modelling.

Comparison	Estimated difference (95% CI)	*P*
SMS self-report minus self-reported rating	8.1 (5.6–10.6)	<0.001
SMS self-report minus self-reported frequency	0.3 (2.2–2.8)	0.81
SMS self-report minus self-reported percentage	−5.2 (−7.7 to −2.6)	<0.001
SMS self-report minus electronic monitoring	9.5 (5.8–13.1)	<0.001

A difference equal to zero implies that average SMS was equal to the other measure. A negative difference implies that average SMS was less than the comparator, while a positive difference means average SMS was greater. 95% CI, 95% confidence interval.

Table 3.

Average adherence by method.

Adherence measures	*N*	No. of records Median (IQR)	Adherence Mean (SD) or *N* (%)	Median (IQR)
Overall				
SMS self-report	348	44 (27–69)	81 (24)	90 (75–97)
Self-reported rating	372	5 (3–7)	73 (16)	75 (65–85)
Self-reported frequency	372	5 (3–7)	81 (16)	85 (73–93)
Self-reported percentage	372	5 (3–7)	85 (20)	94 (75–99)
Electronic monitoring	346	248 (128–421)	70 (28)	79 (50–93)
Detectable tenofovir	227	1 (1–1)	192 (85)	NA
SMS self-report and tenofovir				
SMS self-report	175	7 (6–8)	86 (24)	100 (83–100)
Detectable tenofovir	175	1 (1–1)	158 (90)	NA
SMS and interviewer-administered self-report				
SMS self-report	315	8 (6–9)	85 (24)	93 (83–100)
Self-reported rating	315	3 (2–5)	80 (16)	80 (70–88)
Self-reported frequency	315	3 (2–5)	85 (16)	88 (80–95)
Self-reported percentage	315	3 (2–5)	90 (18)	100 (93–100)
SMS self-report and electronic monitoring				
SMS self-report	322	37 (20–58)	84 (22)	93 (83–98)
Electronic monitoring	322	37 (20–58)	75 (26)	84 (61–96)

‘Overall’ includes the entire dataset from the respective method, while ‘SMS self-report and <method>‘ shows the aligned dataset. ‘*N*’ is the number of participants. IQR, interquartile range; SMS, short messaging service.