Perceptions of a mobile phone-based approach to promote medication adherence: A cross-sectional application of the technology acceptance model

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ABSTRACT

Background: In several African and Asian countries, callers to mobile phones sometimes hear a song or message in place of the typical ringing sound. This application, called caller tunes, may offer a unique opportunity to promote medication adherence that is yet to be explored.

Objectives: Assess the application of the technology acceptance model to a potential caller tunes approach designed to enhance medication adherence, with a specific focus on the interrelationships of perceived ease of use, perceived usefulness, cost, and intention.

Methods: Data from a cross-sectional sample of 996 adult mobile phone users in Ghana, approximately half of whom were current caller tunes users, was examined using exploratory factor analysis for scale evaluation and structural equation modeling to assess associations among perceived ease of use, perceived usefulness, and cost on intention to use mobile phone caller tunes to promote medication adherence.

Results: Consistent with the technology acceptance model, intention to use the caller tunes as a means of enhancing medication adherence was higher among those who viewed the application positively in terms of ease of use and usefulness. Among those who were already caller tunes users, availability as a free download was also associated with more positive intentions.

Conclusion: The present study provides preliminary evidence in support of caller tunes as a novel strategy to promote medication adherence. Future studies interested in using this approach would be advised to consider factors such as participants' current use of caller tunes, age, availability as a free download, and perceptions of ease of use and perceived usefulness of the approach as potential moderators of study outcomes.

1. Introduction

1.1. Medication non-adherence and mobile phone-based interventions

Medication non-adherence is a public health challenge worldwide.[1] While adherence to medication is critical to patient care and optimal health outcomes, the challenge of non-adherence is common, resulting in poor health outcomes, high morbidity and mortality rates, and increased health care costs.[1–3]

Some advances have been made in explaining and improving adherence using theories such as social cognitive theory, health belief model, transtheoretical model, and information-behavior-skill model, self-management theory, and theory of planned behavior or reasoned action.[4]

Moreover, several mobile phone-based interventions for addressing medication non-adherence exist.[5–8] To date, most of the mobile phone-based interventions have focused on the use of text messages to enhance medication adherence for diseases such as hypertension,[9,10] HIV,[11–15] diabetes,[16–18] and asthma.[19] While the use of text messages has had promising results, illiteracy is a major challenge to the widespread implementation in many populations.[20] For example, in Cameroon, a text message-based intervention did not significantly improve adherence to antiretroviral medications.[13] In contrast, a recent study from Thailand showed that a mobile phone call intervention improved adherence in a predominantly rural population where literacy may have limited the impact of a text messaging approach.[21] Unfortunately, relative to text messaging, a phone call approach may potentially be limited by personnel costs.[22]

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1.2. A new communication approach to addressing medication non-adherence

A mobile phone-based feature that has not yet been tested for addressing medication non-adherence is caller tunes, also called ringback tones. Caller tunes is a mobile phone service that provides songs, voice recordings, or other sound effects that play for callers while they wait for the call receiver to answer.[23] This service is widely popular in Sub-Saharan Africa and Asia, where it is often used to promote religious messages and popular songs. For example, an initiative in India that was implemented in 2013 used the voices of celebrities as caller tunes to increase awareness of issues such as breast and cervical cancer, diabetes, obesity, stroke, stress and cardiovascular diseases[23]; however, the empirical impact of the initiative remains unknown.

The use of caller tunes to address medication non-adherence will require some conditions to be investigated or fulfilled. First, telecommunication companies must allow caller tunes to be available for download and use on their networks. Second, caregivers, relatives and friends of individuals with medical conditions who are having difficulty with medication adherence must be willing to download caller tunes onto their mobile phones. Third, the effect of caller tunes on medication adherence will need to be studied, ideally following a theoretical framework that is known to support medication adherence.[24]

1.3. Technology acceptance model, medication non-adherence and caller tunes

Caller tunes can be considered a relatively new technology; thus, it would be prudent to study the extent to which potential users may be interested in using it to address health challenges including medication adherence. Existing studies provide modest support for the information-motivation-behavioral skills model[25] and health belief model[26] in understanding medication adherence behavior. While respecting the benefits of these prior approaches, the technology acceptance model (TAM) [27] may be a particularly well-suited method of studying adoption of innovation mobile phone technology. According to this model, intention to use a particular technology is shaped by both perceived ease of use and perceived usefulness, and intention in turn shapes actual behavioral adoption of the technology.[27] Importantly, several studies of mobile phone technology adoption have also shown that ease of use and usefulness can interact, with perceived ease of use increasing perceive usefulness.[28,29] Extensions to the model have also been considered, with one study finding that cost did not influence intention to use smart meter (an electronic device that records electric energy consumption data),[30] whereas another found that cost did influence acceptance of mobile payment services.[31] Although the technology acceptance model has received relatively little attention to date in medication adherence research,[32] one recent study showed that providing training using TAM as a framework could increase the intention to use a smartphone medication reminder app[33] and another found the model to be useful in designing mobile health interventions for users with low literacy in resource-limited settings.[34]

1.4. Study Aim

To help inform future intervention development, the present study used the technology acceptance model to assess the relationship among key constructs of perceived ease of use, perceived usefulness, and intention to use caller tunes to promote medication adherence.

2. Methods

2.1. Study design overview

This study was conducted as part of a larger cross-sectional survey of the feasibility of using mobile phone caller tunes to address three health challenges: blood donation, medication safety and medication adherence.

2.2. Study sample

Individuals at least 18 years of age who understand English language based on self-report completed a structured questionnaire at voluntary blood donation sites, such as educational institutions and workplaces in Accra, Ghana. Data were collected between October 2016 and December 2016. This study used a purposive sampling procedure because it was not feasible to obtain a list of full potential respondents at blood donation sites. The detailed methods used in the related projects have been described elsewhere,[35,36] and respondents in these prior publications are the same as the current report.

The structured questionnaire was administered by trained interviewers to limit potential bias. Participation was voluntary and written consent was obtained before participating in the anonymous survey. Almost all (i.e., 956/965, or 99%) of the eligible respondents who were approached at the blood donation sites participated in the medication adherence study. The few eligible respondents chose not to participate because they did not have time. Respondents answered TAM-related questions on medication adherence, blood donation, and adverse drug reactions as well as sociodemographic and health related questions. In return for their participation, they received 5 Ghana cedis (about 1 US$).

2.3. Model constructs and hypotheses

To better understand the determinants of using mobile phone caller tunes on medication adherence, we examined three constructs proposed in the adopted TAM: perceived ease of use, perceived usefulness, and intention to use mobile phone caller tunes on medication adherence. Offering caller tunes "free of cost" was also examined as another potential contributor to respondent intention to use the mobile phone application. Fig. 1 illustrates the four main hypotheses:

H1. Perceived ease of use is positively related to perceived usefulness of caller tunes,

H2. Perceived ease of use is positively related to intention to use caller tunes,

H3. Perceived usefulness is positively related to intention to use caller tunes,

H4. A cost-free caller tunes is positively related to intention.

The ethics application for conducting the study was approved by the Institutional Review Board of the Texas A&M University (IRB2016-0655D) and the research ethics committee of the Ghana Health Service (GHS-ERC 05/08/16).

2.4. Instruments

For each of the following constructs, respondents rated each item on a 7-point scale ranging from 1 (Strongly Agree) to 7 (Strongly disagree).

2.4.1. Perceived ease of use

Respondents who already had caller tunes on their phones responded to seven items related to perceived ease of use, namely: 1) "I found caller tunes easy to download", 2) "Learning to download caller tunes was easy", 3) "Using caller tunes is easy", 4) "Instruction for getting the caller tunes is clear and understandable", 5) "It is easy to get caller tunes from my mobile telecom operator", 6) "It is easy for my phone to download a caller tunes", and 7) "It is easy to remember how to download a caller tunes". Respondents who did not already have caller tunes responded to three items on perceived ease of use, namely: 1) "I think it would be easy to download caller tunes", 2) "I believe that the instruction for downloading the caller tunes would be clear and easy to understand", and 3) "I think that caller tunes is a flexible technology to interact with."
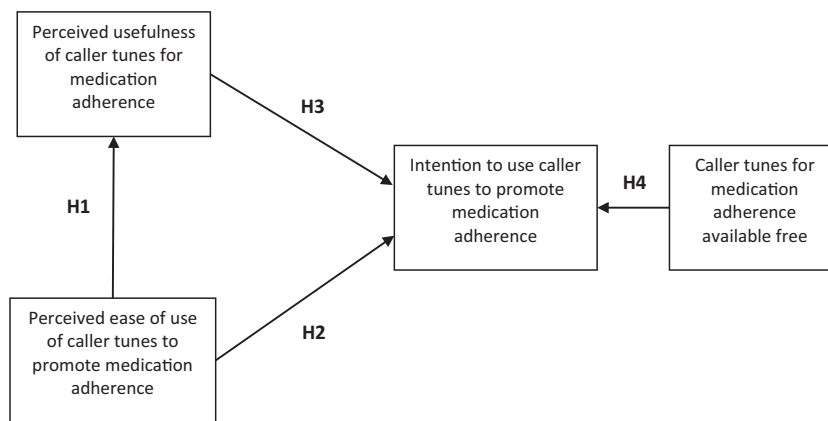
Fig. 1. Hypotheses of the adopted technology acceptance model.

2.4.2. Perceived usefulness

Respondents with and without caller tunes responded to three items on perceived usefulness, namely: 1) "Using caller tunes for encouraging patients to take their medications as directed would help them complete taking their medications", 2) "Using caller tunes for encouraging patients to take their medications as directed would help them get better health outcomes", and 3) "Overall, caller tunes is useful for promoting adherence to medications".

2.4.3. Intention to use

All respondents rated the statement: "I intend to use caller tunes for promoting medication adherence by patients".

2.4.4. Cost

All respondents rated the perceived importance of cost by indicating if their use would be influenced by "Mobile telecommunication network makes it free to download".

The questionnaire also captured demographic characteristics such as age, educational level and use or non-use of mobile phone caller tunes. Table 1 provides the definition of the constructs as used in the study.

The questionnaire was developed using TAM constructs validated in previous studies, which are not related to caller tunes.[26–34,37] Seven-point Likert scale for TAM constructs was used based on evidence in the literature on TAM measurements.[26] Prior to using the questionnaire for the study, it was pilot-tested among 10 respondents for understanding and ease of administration.

2.5. Statistical analysis

Descriptive statistics summarize the demographic characteristics of the sample. After dividing respondents into caller tunes users ($n = 486$) and non-users ($n = 470$), exploratory factor analysis (EFA) for scale evaluation of the proposed constructs and structural equation modeling (SEM) for hypothesis testing were employed. In other words, EFA and SEM were

Table 1
Constructs tested for exploring the utility of using mobile phone caller tunes to promote medication adherence.

Construct	Definition
Perceived Ease of Use	The degree to which respondents feel it is easy to download caller tunes onto a mobile phone to promote medication adherence
Perceived Usefulness	The perception by respondents that caller tunes could be a useful technology for improving medication adherence
Intention to Use	Respondents goal to use mobile phone caller tunes to promote medication adherence
Free of Cost	Making caller tunes free to those who intend to download it for promoting medication adherence

conducted on the same samples after splitting the samples into two: those with caller tunes and those with no caller tunes. We assessed values of the Kaiser–Meyer–Olkin (KMO) test for sampling adequacy and Bartlett's test of sphericity for the appropriateness of conducting factor analysis. We set the criteria for appropriateness of conducting EFA: ≥ 0.5 (0.6 as mediocre, >0.9 as exceptional) for KMO test and $p < 0.001$ for Bartlett's test of sphericity.[38] For scale evaluation, we computed Cronbach's alpha and composite reliability for reliability and average variance explained for validity. We examined if the obtained values met acceptable criteria: Cronbach's alpha >0.7, the composite reliability score > 0.7 and average variance extracted >0.5.[39] Structural equation modeling was conducted using robust maximum likelihood estimation, suitable for large sample sizes of greater than 400 and data with non-normal distribution and high values of kurtosis.[40] Goodness-of-fit indices for each model was assessed using the ratio of chi-square to its degrees of freedom (χ^2/df) < 5.0, Tucker–Lewis index (TLI) ≥ 0.95, comparative fit index (CFI) ≥ 0.95, and root mean square error of approximation (RMSEA) < 0.08.[41,42] Descriptive statistics and exploratory factor analysis were performed using SPSS Version 25 (IBM SPSS Statistics) and structural equation modeling was conducted using Mplus 8.4.[43]

3. Results

3.1. Respondent characteristics

The majority of the 956 participants were male (66.6%), between 18 and 30 years of age (87.5%), rated their health as good or excellent (78.7%), and had at least a senior high school education (89.7%). The sample was almost equally split in terms of the proportion who did (50.8%) and did not (49.2%) use caller tunes. As shown in Table 2, as a group, the caller tunes users were younger ($p < 0.001$) and less educated (p < 0.001) than those without caller tunes, but the groups did not differ significantly by gender ($p = 0.801$) or self-rated health ($p = 0.823$).

In Ghana, primary education is up to the sixth grade. Middle school education used to follow primary education until in the late 80's when it was split into junior high school (grades 7–9) and senior high schools (grades 10–12). Senior high school graduates usually pursue further education at the university or other tertiary educational institutions. Most caller tunes users (44.7%) had pursued education beyond senior high schools (Table 2).

3.2. Reliability and validity of measures

As shown in Table 3, the scales used to assess perceived ease of use and perceived usefulness demonstrated acceptable reliability among both users and nonusers of caller tunes (all Cronbach's alpha >0.81). Construct validity was also supported by the average variance extracted ranging from

Table 2
Characteristics of respondents who did and did not have caller tunes.

		Caller Tunes n (%)	No Caller Tunes n (%)	p
Gender	Male	319 (66.2)	315 (67.2)	0.801
Age in years				< 0.001
	18–20	222 (45.9)	143 (30.5)	
	21–30	197 (40.7)	272 (58.0)	
	31–40	46 (9.5)	39 (8.3)	
	41–50	15 (3.1)	11 (2.3)	
	51–60	2 (0.4)	3 (0.6)	
	>60	2 (0.4)	1 (0.2	
Education				< 0.001
	Primary	12 (2.5)	7 (1.5)	
	Middle school	3 (0.6)	8 (1.7)	
	Junior high school	39 (8.1)	29 (6.2)	
	Senior high school	213 (44.1)	132 (28.1)	
	Above senior high school	216 (44.7)	293 (62.5)	
Self-rated health				0.823
	Excellent	194 (40.1)	192 (40.9)	
	Very good	191 (39.5)	173 (36.9)	
	Good	88 (18.2)	94 (20.0)	
	Fair	10 (2.1)	9 (1.9)	
	Poor	1 (0.2)	1 (0.2)	

Note: For analysis of group differences, age was recategorized into four groups (< 20, 21–30, 31–40, > 40) to satisfy the Chi-square test assumption of at least 5 observations per category.

0.58 to 0.80. Further, sampling adequacy (Kaiser–Meyer–Olkin test values: 0.69–0.90) and sphericity (Bartlett's test: $p < 0.001$) for conducting factor analysis was confirmed. The exploratory approach to test factor loadings found that all the items loaded on the factors as expected.

3.3. Path analyses

As shown in Fig. 2 and Fig. 3, results of structural equation modeling supported hypothesis 1 through 3 regardless of whether respondents were caller tunes users or not. That is, perceived ease of use was positively related to perceived usefulness, perceived ease of use was positively related to intention, and perceived usefulness was positively related to intention to use caller tunes. However, free availability was only significantly related to intention to use caller tunes for medication adherence among those who were already users of caller tunes ($\beta = 0.13$, SE = 0.04, $p < 0.001$), but not among those who were not already using caller tunes ($\beta = 0.06$, SE = 0.04, $p = 0.128$). Overall, these models accounted for 30% of the variance in intention for both caller tunes users and nonusers, with the strongest associations observed between perceived usefulness and intention (0.50–0.52, p < 0.001).

As shown in Table 4, these models showed a strong fit to data among those with caller tunes (TLI = 0.96; CFI = 0.97; RMSEA = 0.05; Chi-square = 2.3) and among those without caller tunes (TLI = 0.99; CFI = 0.99; RMSEA = 0.05; Chi-square = 2.0).

4. Discussion

Consistent with prior studies of the technology acceptance model,[27,28] the results of the current survey revealed a positive relationship between perceived ease of use of caller tunes for medication adherence on perceived usefulness, and both perceived ease of use and perceived usefulness were positively related to intention to use such a mobile phone application. These findings suggest that as people consider caller tunes to be easy to use or to have potential for improving medication adherence, they are
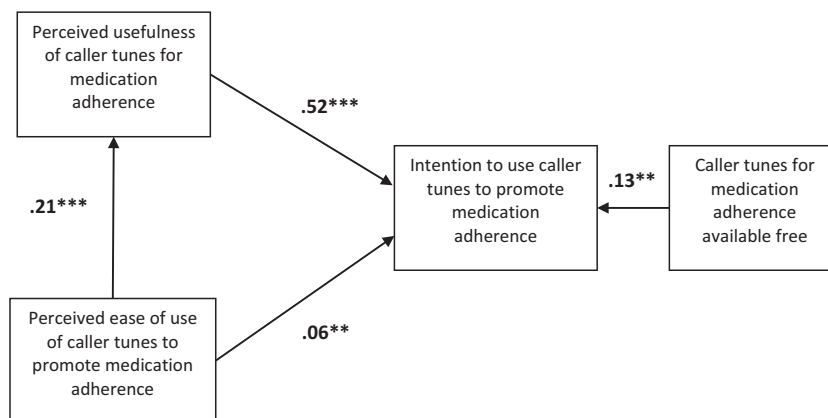
Table 3
Reliability and validity of measures for respondents with or without caller tunes.

		Respondents with caller tunes				Respondents without caller tunes			
Scale/Item	Factor loading	α	Composite reliability	Average variance extracted		Factor loading	α	Composite reliability	Average variance extracted
Ease of use		0.877	0.91	0.58			0.871	0.92	0.80
item 1	0.73						0.90		
item 2	0.79						0.94		
item 3	0.78						0.84		
item 4	0.71								
item 5	0.76								
item 6	0.80								
item 7	0.74								
Usefulness		0.813	0.89	0.73			0.858	0.91	0.78
item 1	0.85						0.90		
item 2	0.88						0.91		
item 3	0.83						0.84		

Fig. 2. Models showing standardized path coefficients for respondents with caller tunes **$p < 0.05$, ***$p < 0.001$.
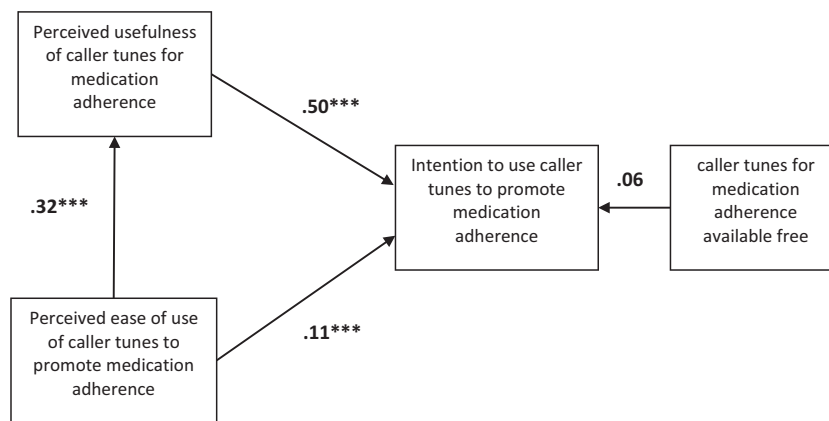
Fig. 3. Models showing standardized path coefficients for respondents without caller tunes **p < 0.05, ***p < 0.001.

Table 4
Global model fit indices for respondents with and without caller tunes.

Fit index	With caller tunes (n = 486)	Without caller tunes (n = 470)	Criteria value[39]
Tucker–Lewis index (TLI)	0.96	0.99	≥ 0.95
Comparative fit index (CFI)	0.97	0.99	≥ 0.95
RMSEA (90% CI)	0.05 (0.04–0.07)	0.05 (0.02–0.07)	< 0.06
Chi square	2.3	2	< 5.00

Note: RMSEA = Root Mean Square Error of Approximation.

more likely to consider having caller tunes with messages or songs on medication adherence to increase awareness of the need to adhere to medications. Interestingly, having caller tunes for medication adherence available free of cost was also significantly associated with the intention to use the application, at least among current users, which agrees with a similar observation found in a previous study of mobile payment services.[30] These findings are not surprising given that users of caller tunes usually pay a monthly fee of the equivalent of 15 US cents, hence future studies and clinical interventions that intend to use caller tunes to aid medication adherence should address the perceived cost to users as a potential barrier. Strategic partnerships with telecommunication providers may help reduce or eliminate such costs. For example, in Ghana, telecommunication providers have corporate social responsibilities including promoting health, and may be willing to have users download caller tunes for free.

To the best of our knowledge, this is the first study to adapt TAM constructs to medication adherence and mobile phone caller tunes, thus making the instrument novel.

The fact that the exploratory factor analyses provide initial support for instrument reliability and validity suggests that this measure can be adapted by other similar caller tunes-based medication adherence studies in the future.

Importantly, model testing revealed a strong fit to the data among those who currently used caller tunes as well as among those who did not. These findings suggest that future planning to test the feasibility of caller tunes to promote medication adherence can consider a broad implementation regardless of current use.

A systematic review on the implementation of mobile health projects in Africa identified factors including ease of use and increased access to the technology as important for implementation success.[44] Given the perceived ease of use of caller tunes to promote medication adherence as identified in the current study, there is a need to further explore its use for improving medication adherence alongside the use of text messages or calls.

A recent review of mobile phone-based interventions for improving adherence to medications for cardiovascular diseases identified text messages as having been used exclusively in 21 of the 27 studies.[45] Moreover, of the 27 studies, none was conducted in Africa, 12 were conducted in China, a multicentre study was conducted in India and Tibet, and one was

conducted in Malaysia. The rest were conducted in Europe and North America. The review's findings suggest a need for exploring the potential use of caller tunes as one of the innovative tools particularly for promoting adherence to medications for cardiovascular and other chronic diseases in Africa and Asia where the technology is most widely used. An important finding that may have implications for the use of caller tunes to address health challenges was the observed relationship between current caller tune use and age and education. Specifically, current users were significantly younger and less educated. This finding must be considered when designing future medication adherence interventions. For example, when using caller tunes to promote adherence to anti-diabetic or anti-hypertensive medications, younger family members of patients could be encouraged to download caller tunes on medication adherence onto their mobile phones. That way, when older family members call the mobile phones of their younger family members, they will be exposed to the medication adherence messages or songs. Caller tunes can be individualized in such a way that only specific callers may be exposed to particular caller tunes. This feature is likely to enhance the feasibility of using caller tunes for designing medication adherence interventions for particular people. Similarly, caller tunes could be considered as a method of preferentially addressing medication adherence issues that more commonly affect younger people by installing the application on the phone of their older relatives or other younger mobile phone users.

5. Limitations

As with all studies, the present investigation has several limitations that must be considered in interpreting the findings. First, the data are subject to social desirability effects (i.e., attempting to present oneself in the most desirably light) because it relied on interviewers to get information from respondents. Although this is a limitation, it is also a strength in that it allowed us to obtain data regardless of respondent literacy. Second, as a cross-sectional design, causal implications cannot be derived from the results. Thus, additional testing will be required to examine how responses relate to actual behavior examined longitudinally. Third, intention was assessed using a single item and although this has been used successfully in similar research,[46] future studies should consider a multiple-item measure of intention. Fourth, because the items of intention and perceived usefulness were worded generally, the findings may reflect respondents' general perception of medication adherence rather than their own medication adherence. Finally, because we did not specifically examine responses among those who were currently taking chronic medications, or who had specific health issues such as diabetes or hypertension, future studies will need to consider generalizability to specific patient populations. These limitations notwithstanding, the present findings can inform the development and testing of future caller tunes intervention studies aimed at promoting medication adherence.

6. Conclusion

The present study provides preliminary evidence in support of caller tunes as a novel strategy to promote medication adherence. Future studies interested in using this approach would be advised to consider factors such as participants' current use of caller tunes, age, and perceptions of ease of use and usefulness of the approach as potential moderators of study outcomes. This study has implications for using caller tunes for promoting medication adherence in similar settings where the technology is widely used. For example, given that intention of respondents with caller tunes to use the technology correlates with caller tunes being made free of cost, scholars and practitioners may need to consider innovative strategies to make it available for free. This can be achieved through strategic partnerships with telecommunication companies that already implement projects in low- and middle-income countries as part of their corporate social responsibilities.

Declaration of Competing Interest

None.

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