

Advancing Equity in the Mental Healthcare Supply Chain: Empirical Evaluation of a Mobile Application

Adam Moen
University of Minnesota
Real EmPowerment Solutions

Co-authored with:

Kingshuk K. Sinha
University of Minnesota

Yi Tang
University of Minnesota

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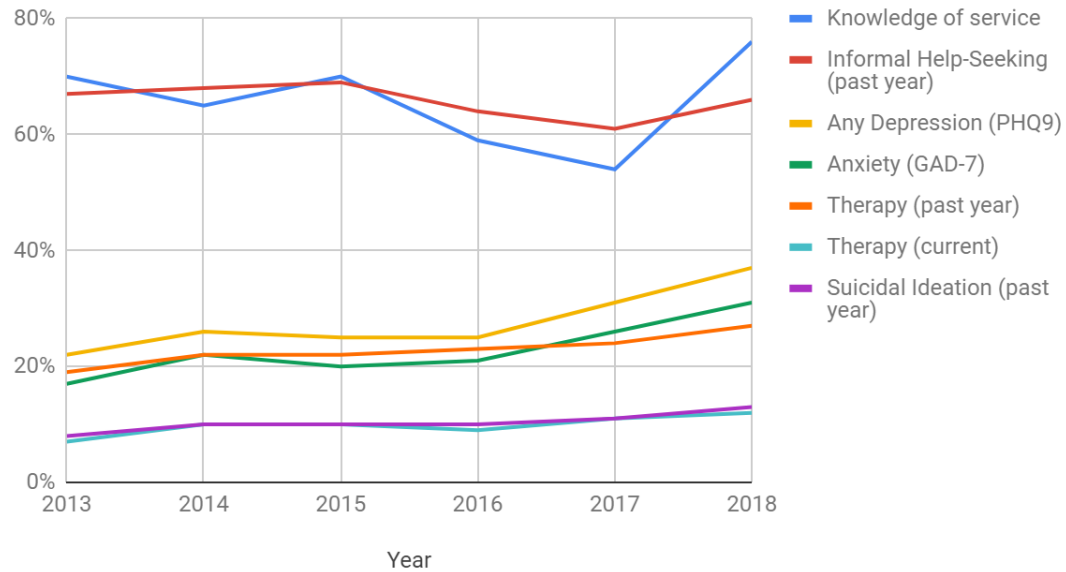
Agenda

- > Introduction / motivation for Phase I
- > Literature review / hypotheses
- > Data / analysis of Phase I
- > Conclusion of Phase I
- > Next Steps for Phase II

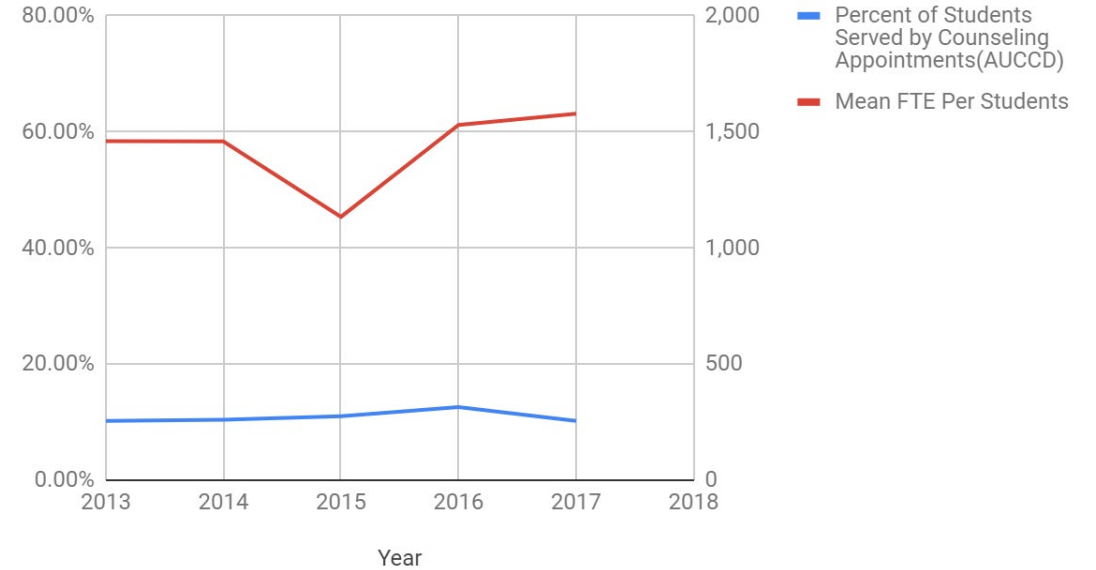
INTRODUCTION / MOTIVATION

Mental health has a supply chain problem...

From Health Minds Annual Study (University of Michigan)



From Annual Directors Survey (AUCCCD)

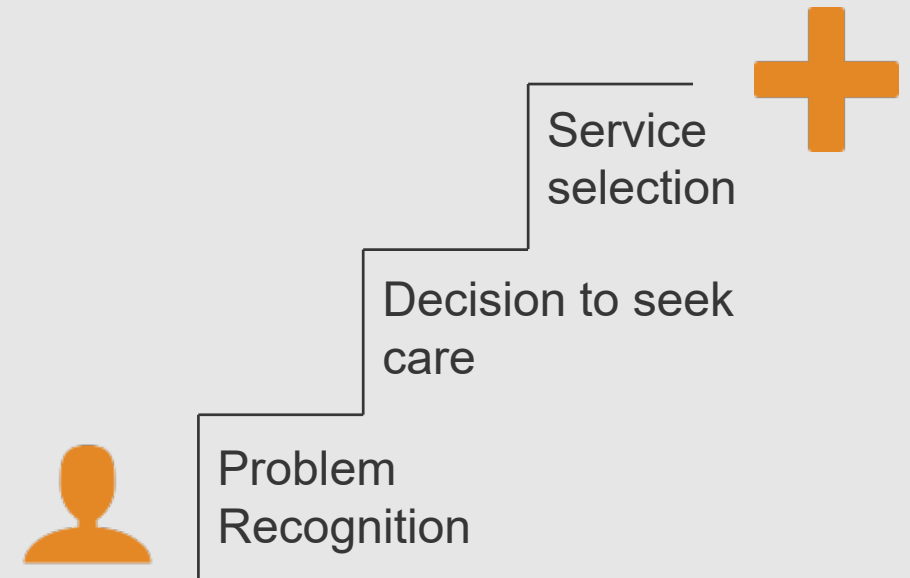


Consumption varies by demographics

- > 2016 National Survey on Drug Use and Health (NSDUH) by the Substance Abuse and Mental Health Services Administration (SAMHSA)
 - > Consumption rates of mental health services: 43.1% of adults with any mental illness received treatment in a given year
 - > Male adults (33.9%)
 - > Young adults aged 18-25 (35.1%)
 - > Hispanic (31%)
 - > Black (29.3%)
 - > Asian (21.6%) adults have significantly lower-than-average treatment rates while experiencing similar or often higher levels of distress than their peers.⁵
- > Findings supported by studies on university students
- > Disparities exist
 - > Personal stigma was higher among students with any of the following characteristics: male, younger, Asian, international, more religious, or from a poor family (*Eisenberg, 2009*)
- > African Americans do not seek services as readily as Caucasians (*Barksdale, 2008*)

Increase acceptability for the right consumer

- > Dr. Sheth's 4 A's:
 - > Awareness, affordability, and access
 - > Acceptability
- > Progress in access, affordability, and awareness
 - > Decrease in stigma, expansion of digital services such as teletherapy/psychiatry, and online CBT modules or other community support platforms
- > Acceptability of intervention is still largely unknown



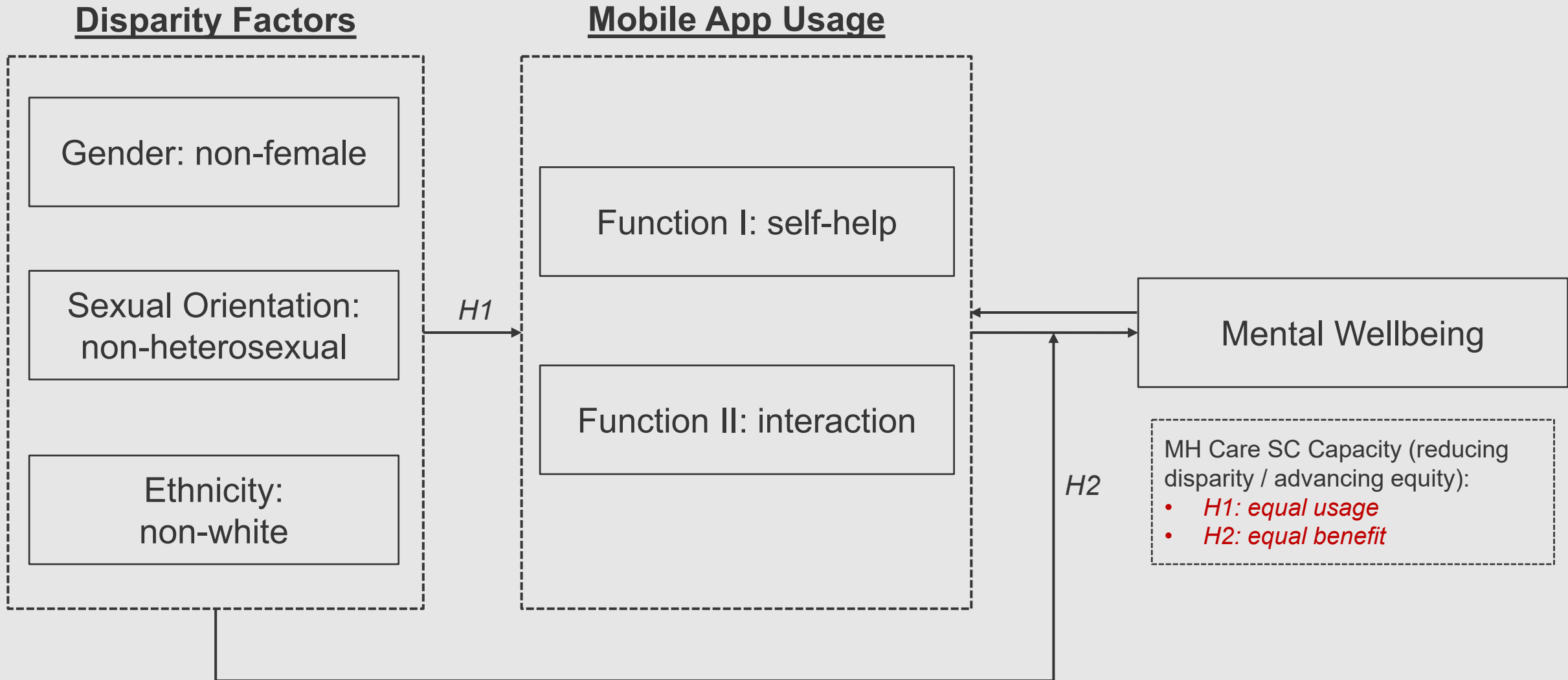
*Mental health help-seeking model (*Cauce, 1996*)

Research questions – Can mobile apps reduce mental health care disparities?

1. (Equal usage) Do users from underserved population use mental health mobile app equally?
2. (Equal benefit) Do users from underserved population benefit equally from using mental health mobile app?

LITERATURE REVIEW / HYPOTHESES

Theoretical Framework



Theory - mechanisms of mental health care disparities

- > Treatment preferences
 - > Significantly lower probability of using **outpatient services** among blacks and Hispanics (*Scheffler&Miller 1991*)

- > Social stigma / self-stigma
 - > Judgmental, diagnostic **labels** creates stigma
 - > Social stigma: people with mental health problems were dangerous and hard to talk to (*Crisp et al. 2000*)
 - > Self-stigma: perceptions of discrimination (*Link, et al. 1989*) which lead to poorer treatment outcomes (*Perlick, et al. 2001*)
 - > People from collectivist communities (Asians etc.) have more difficulty in being open to out-group strangers (*Leong et al., 1995*)

- > Cognitive barriers
 - > Black people: more likely to report that **fear / mistrust / skepticism of treatment** had prevented them from seeking MH care (*Sussman et al. 1987*)

- > Masculine role socialization / social norms / cultural norms
 - > Low self-awareness or “without words for emotions”: not realizing that they are, for example, depressed
 - > Males * black subpopulation - "tough it out" on his own / not supposed to express vulnerability or caring (*Journal: Psychology of Men and Masculinity*)

- > Language barriers, geographic accessibility and decision making: Race/ethnicity or SO match

Theory – mobile app as an intervention to reduce disparities

Features of mental health mobile apps

- > Create self-awareness and alerts to action (masculine role socialization / social or cultural norms)
- > Nonjudgmental, non-diagnostic and non-clinical wellbeing tracking (stigma / treatment preferences) (*Corrigan 2007*)
- > Anonymity (stigma / masculine role socialization / social norms / language barriers etc.)
- > Social support from peers (*Yan & Tan 2014*)
 - > Informational support / emotional support (cognitive barriers / stigma)
 - > Stress-buffering model: social support conveys its greatest mental health benefit at the highest level of stress exposure (socially disadvantaged population)

Self-help:
Mental wellbeing
tracking

Interaction:
Anonymous online
community

Hypotheses

H1: (Equal usage) The underserved population (in terms of gender, sexual orientation and ethnicity) access the app not less frequently than their counterparts who are not underserved.

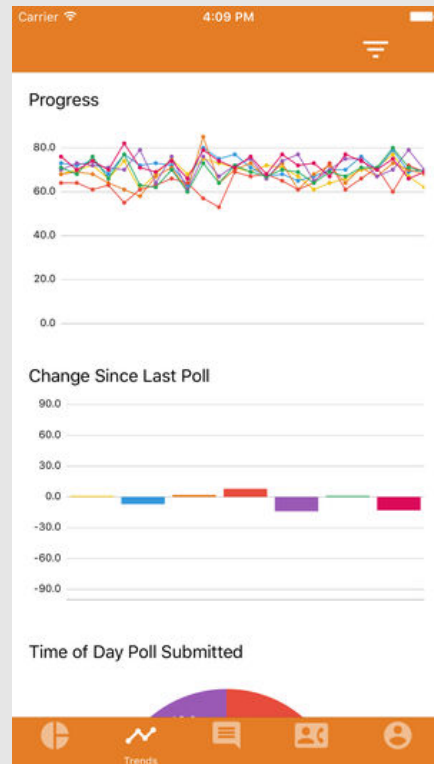
H2: (Equal benefit) The underserved population (in terms of gender, sexual orientation and ethnicity) benefit more by using the mobile apps than their counterparts who are not underserved.

DATA / ANALYSIS

Empirical Setting / Data Source

> Marbles

- > # of users (as of 02/02/2018): 2713
- > **Mental wellbeing reflection / tracking**



Question	Scale
1. (Sense of Self & Belonging) How connected, supported, comfortable, and included do you feel?	0-100
2. (Purpose & Emotional Clarity) How clear, purposeful, intentional, and intuitive do you feel?	
3. (Decisions, Commitment & Reliability) How trusting, reliable, decisive, and committed do you feel?	
4. (Relationships & Contentment) How open, accepting, and content do you feel?	
5. (Work, Academics & Motivation) How influential, valuable, and capable do you feel?	
6. (Stress & Emotional Wellbeing) How sparked, energized, and inspired do you feel?	
7. (Sleep, Exercise & Nutrition) How grounded, safe, and physically healthy do you feel?	

Face Validity of the Marbles 7-item Scale

- > This scale is inspired by the Chakra system well-being model as well as Patient Health Questionnaire-9 (PHQ9) and Generalized Anxiety Disorder 7-item (GAD7)
- > Average score of Marbles 7-item scale is found to be significantly correlated with both PHQ9 and GAD7 (*Mendenhall&Moen, 2016*)

Empirical Setting / Data Source (Cont'd)

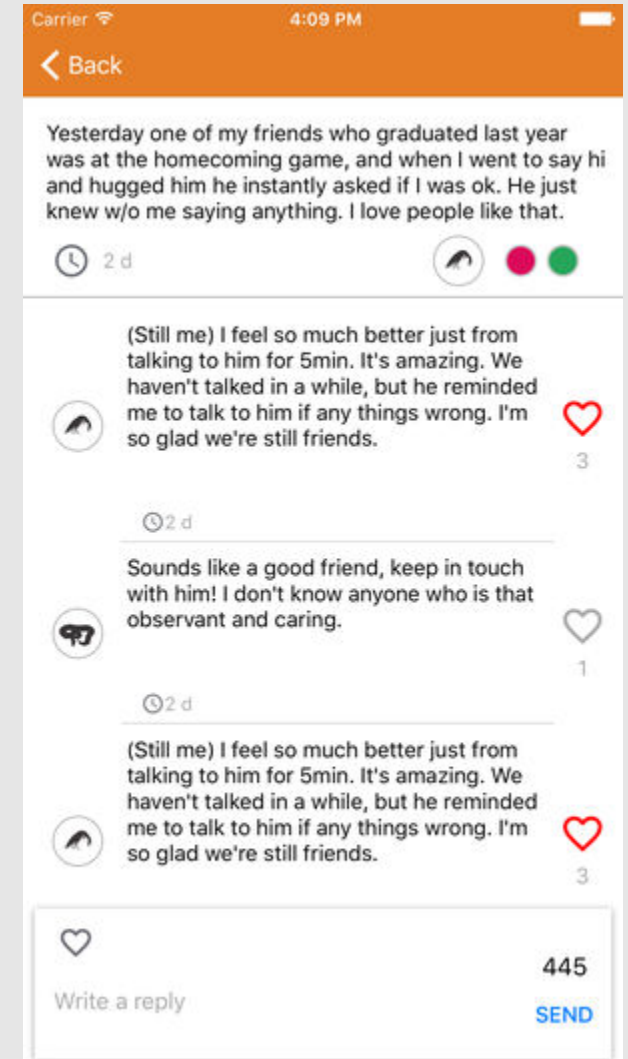
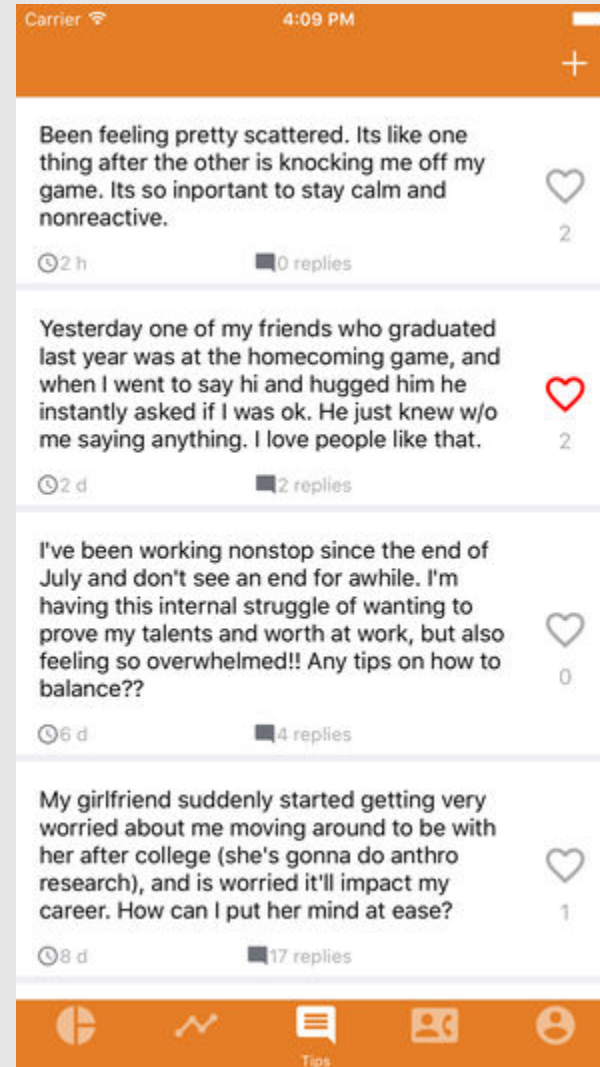
> Marbles

- > # of users (as of 02/02/2018): 2713
- > **Anonymous online community**

*"I have taken therapy at one point. But I simply couldn't open up because I had such a strong **fear of talking to them and opening up**. I do take medication for my anxiety and it has helped a little."*

*"The world is crushing me. So much is happening in my life that I can't handle. My depression is worsening and I thought about suicide last night. I missed my alarm because I didn't want to wake up. It's been real hard the past 3 days. This is **the worst I've ever felt in my life**."*

"I don't know how to convince my doctor that there is something wrong with me. I tell her that I have severe mood swings. One moment I can be really happy, another I don't even want to get out of bed. She says that I'm just being a moody teen. Any advice? I truly think something is wrong! :("

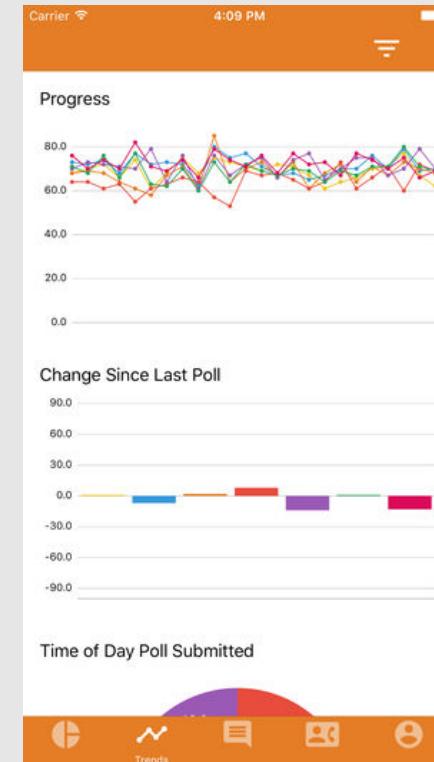


CONCLUSION OF PHASE I

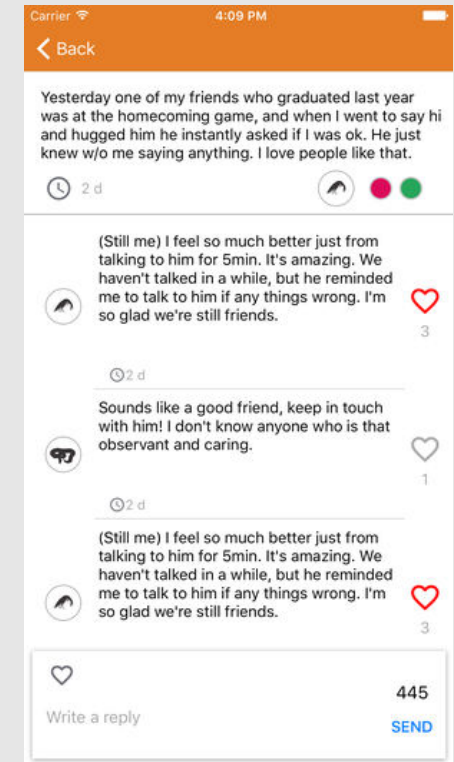
Phase I Conclusions

- > Mobile apps create an **equal platform** for **underserved population** in conventional mental health care supply chain
 - > Beyond affordability, accessibility
 - > Create awareness and willingness to seek help (*Sinha&Kohnke 2009*)
- > Minority sexual orientation and race/ethnicity population gain **more benefit** from using the self-help tools
- > Peer-based anonymous community may **do harm** to certain users' mental wellbeing
 - > More deliberate design is urged
 - > Professionals may be necessary
- > Mobile apps are catching people in crisis
 - > Quickly sense and respond: machine learning algorithm
 - > Professional resources, referral

Wellbeing tracking



Anonymous Community



NEXT STEPS FOR PHASE II

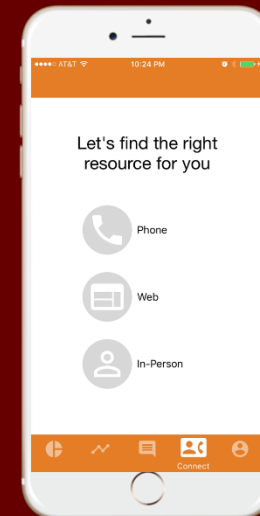
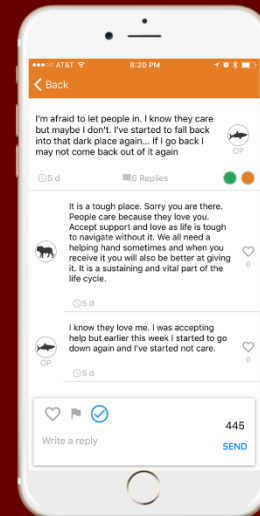
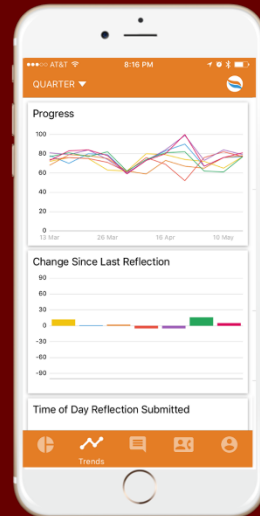
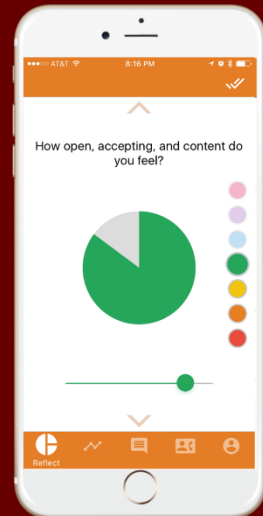
MACHINE LEARNING

A better bridge to support

Problem
Recognition

Decision to
seek
care

Service
selection



Sample linguistic model

	User_ID Text – Initial Post (OP)
#OP #intent #depressed	111041 How should I kill myself ?
	Replies
#emotionalsupp	142636 Don't do it. Think about how much pain it will cause others
#reply #OP #hopelessness	111041 I just don't know what to do to fix myself
#companionship	42793 Been there too. It could start with a simple change in mindset. What do you mean by 'fix yourself'?
#companionship	99991 I'm in the same boat, OP 💎💎I have a plan too. I don't feel comfortable sharing because I guess I don't want you to take your life either 💎💎
#emotionalsupp	42793 If you don't want someone else to take their life turtle, wouldn't that same sentiment apply to you? Others don't want you to take your life either.
#informationalsupp	42793 I'm must protest as well. Sometimes it feels like it truly is the only or the easiest way out. But There is so much life and opportunity that would be cut short and wouldn't be experienced. Please don't cut it short!
#companionship #informationalsupp	577 Sorry you are feeling that pain. I just can't recommend killing oneself as I felt that way and decided not to and I am so grateful. There are ways out of this pain. I do understand how torturous it can feel. Call the suicide hotline or open up here. Many have felt so low and walked out. You can too.
#emotionalsupp #informationalsupp	52015 You say you need to "fix" yourself. You may feel broken, but there are ways to put yourself back together without dying. There are people who want to help you feel better. Please try reaching out to professional help. You are worth it and your life is worth it!
#emotionalsupp	42793 ;) hope you are doing well buck!

Join the project!



Adam Moen
Research Associate

- > Adam Moen
- > moenx200@umn.edu
- > +1 651.329.4375

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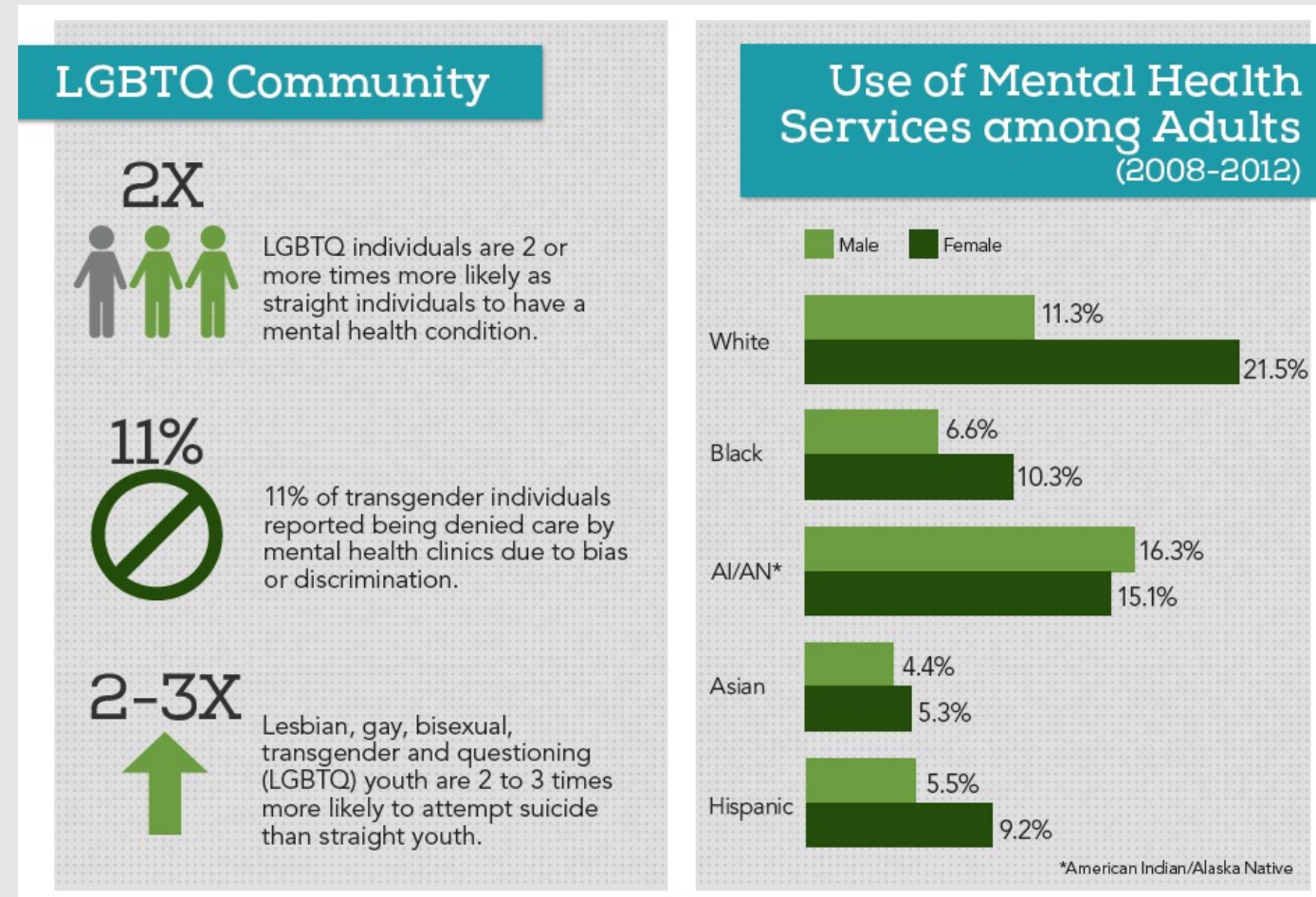
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Appendix

Mental health consumption disparities exist

- > Disparity as a mental health supply chain issue is overlooked by
 - > Practitioners: focus on affordability / accessibility / awareness (*Sinha&Kohnke 2009*)
 - Improving MH of the population overall V.S. **narrowing** differences between advantaged and disadvantaged groups
 - E.g., huge gap for black and Hispanic physician demands
 - > OM / SCM scholars: few mental / behavioral health
 - Supplier-centered disparity: bias / discrimination
 - Demand side-centered disparity: **willingness**

- > Underserved population in mental health care delivery supply chain:
 - > Gender: male and other gender identity
 - > Sexual orientation: heterosexual, bisexual and other identity
 - > Race/ethnicity: Non-white



Source: US National Alliance on Mental Illness (NAMI)

Literature Review / Potential Contribution

- > Status quo and causes of mental health care disparities
 - > Eliminating health disparities is a fundamental, though not always explicit, goal of public health research and practice. / Disparity results from social factors which are unjust and avoidable (*Adler&Rehkopf 2007*)
 - > Mechanisms of mental health disparities (*Aneshensel 2009*)
- > Effects of mobile app on mental health
 - > Meta-analysis and review paper: significant reductions in depression, stress and substance use (*Donker et al. 2013, Payne et al. 2015*)
 - > Evidence-based recommendations for MH app development (*Bakker et al. 2016*)
- > Mental health studies in OM/SCM community
 - > Underserved population in less developed areas benefit more from mental health care quality improvement initiatives at primary care setting (*Zepede&Sinha 2016*)

**Empirically investigate
the effectiveness of
mobile apps as a specific
intervention to reduce
mental health care
disparities.**

Data and Measures

> Data

- > Record level: every wellbeing reflection poll taken / post / reply / like
- > User level: demographic data + aggregated record level data

> Dependent / Independent variables

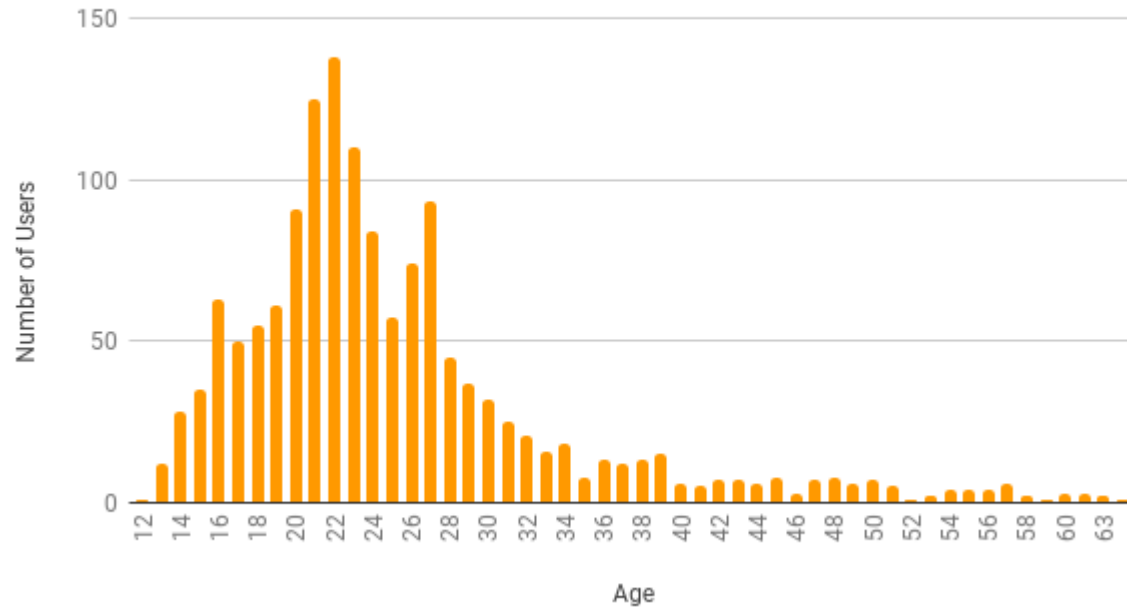
- > *usage_tracking*: user usage of mental wellbeing tracking function (**count data**)
- > *usage_community*: user usage of anonymous community function (**count data**)
 - number of posts written + number of replies written + number of likes given
- > *nnotif_tracking*: amount of app notification received for wellbeing tracking function
- > *nnotif_community*: amount of app notification received for peer-based anonymous online community function
 - number of replies received + number of likes received
- > *wellbeing*: average score of the 7 user-reported mental wellbeing reflection questions
- > age / gender / sexual orientation / race and ethnicity *dummies*: 0/1

> Control variables

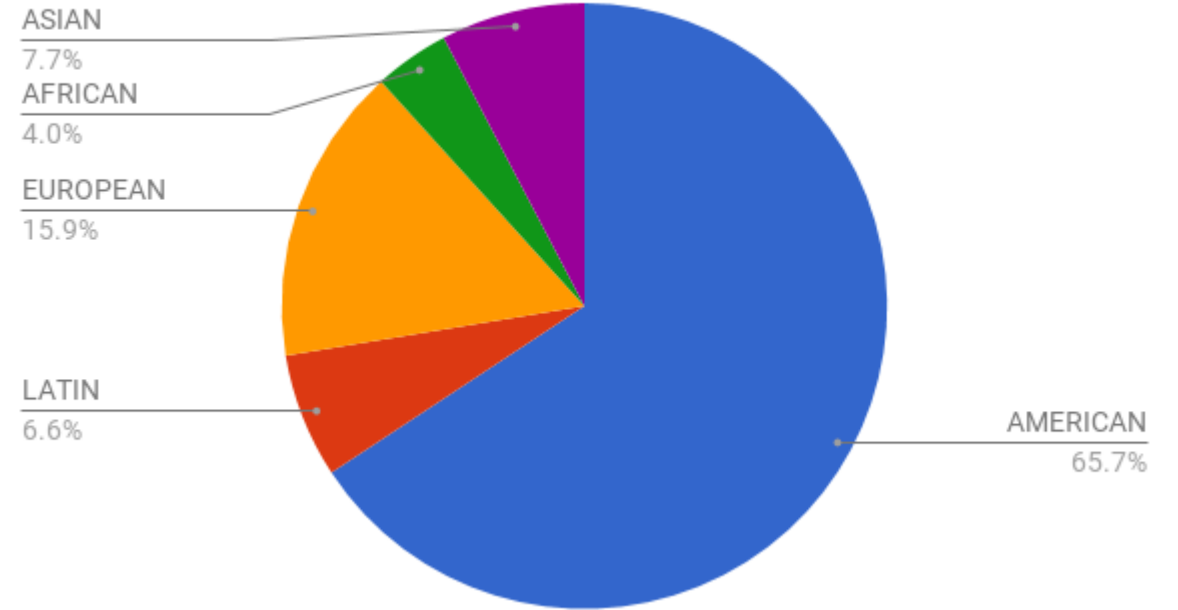
- > *In_tenure*: log of tenure days in the app since sign-up

Sample

User Age

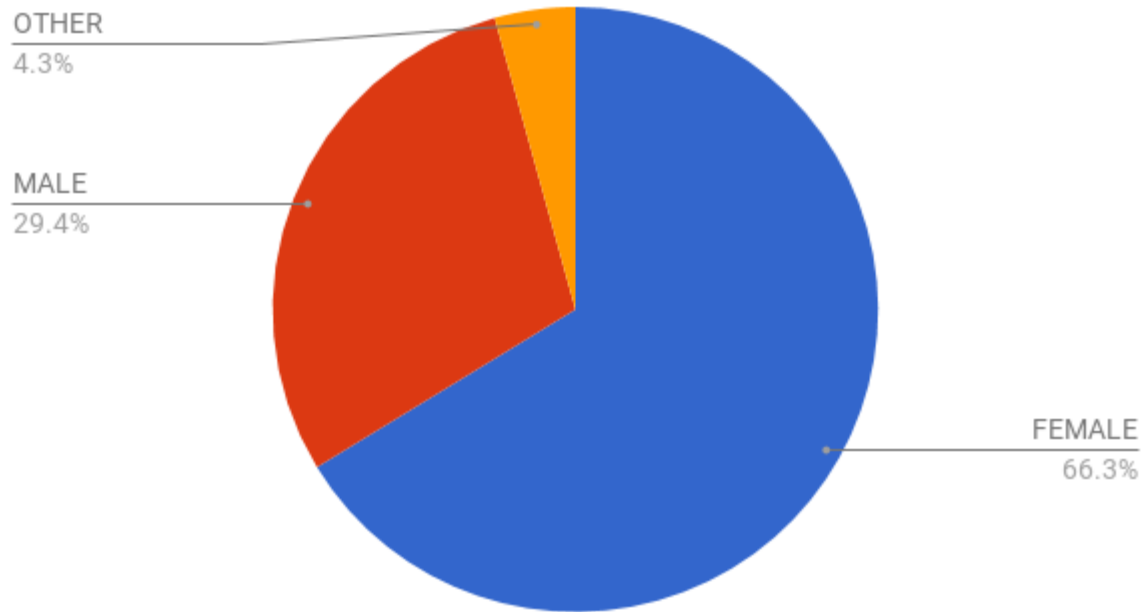


User Ethnicity (77% of users reporting)

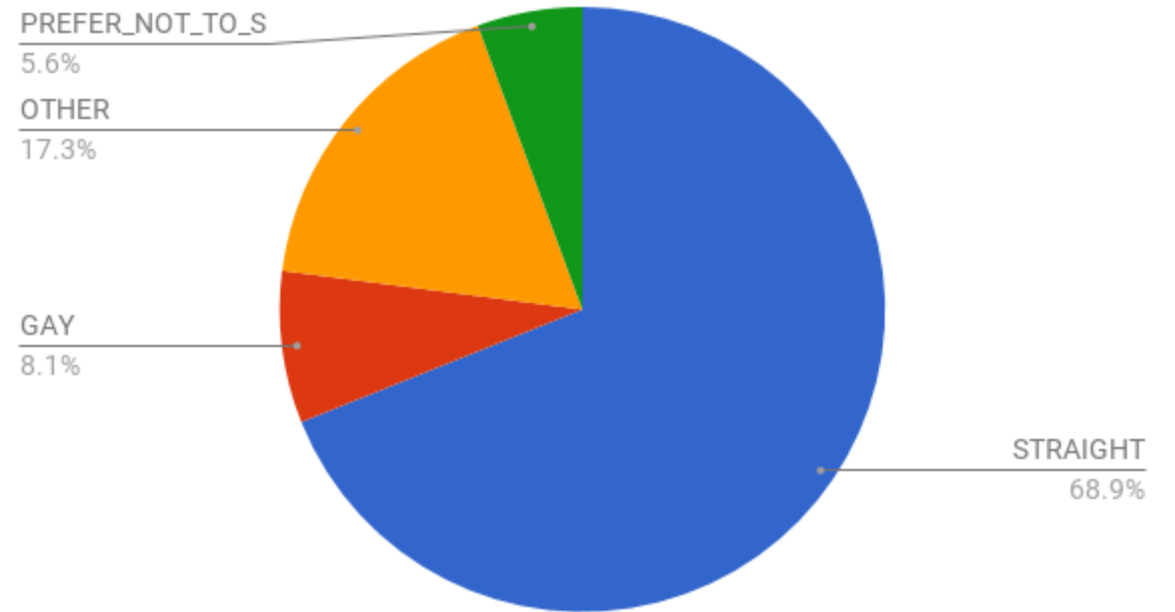


Sample

Gender (77% of users reporting)



Sexual Orientation (81% of users reporting)



Descriptive Statistics: *usage_tracking*

<i>usage_tracking</i>	N	Mean	S.D.	Min	Median	Max
Gender:						
Female	1237	4.36055	7.151459	1	2	59
Male	478	4.707113	8.924209	1	1	63
Other	86	9.034884	14.09418	1	3	61
Not reported	428	2.901869	5.607764	1	1	58
Sexual Orientation:						
Heterosexual	1254	4.42185	7.685344	1	2	63
Homosexual	148	5.27027	10.63021	1	1	59
Other	369	5.623306	8.608742	1	2	56
Prefer not to answer	92	5.228261	9.905158	1	2	61
Not reported	366	2.136612	3.681561	1	1	45
Race/Ethnicity:						
American	1207	5.020713	8.843699	1	2	63
European	212	4.033019	7.432084	1	1	56
African	26	4.653846	6.973907	1	2	27
Asian	104	4.5	7.347148	1	2	42
Latino	89	3.404494	5.06485	1	1	27
Multiple	175	5.04	7.515012	1	2	55
Not reported	416	2.341346	4.140173	1	1	45
Overall:	2229	4.335128	7.765662	1	2	63

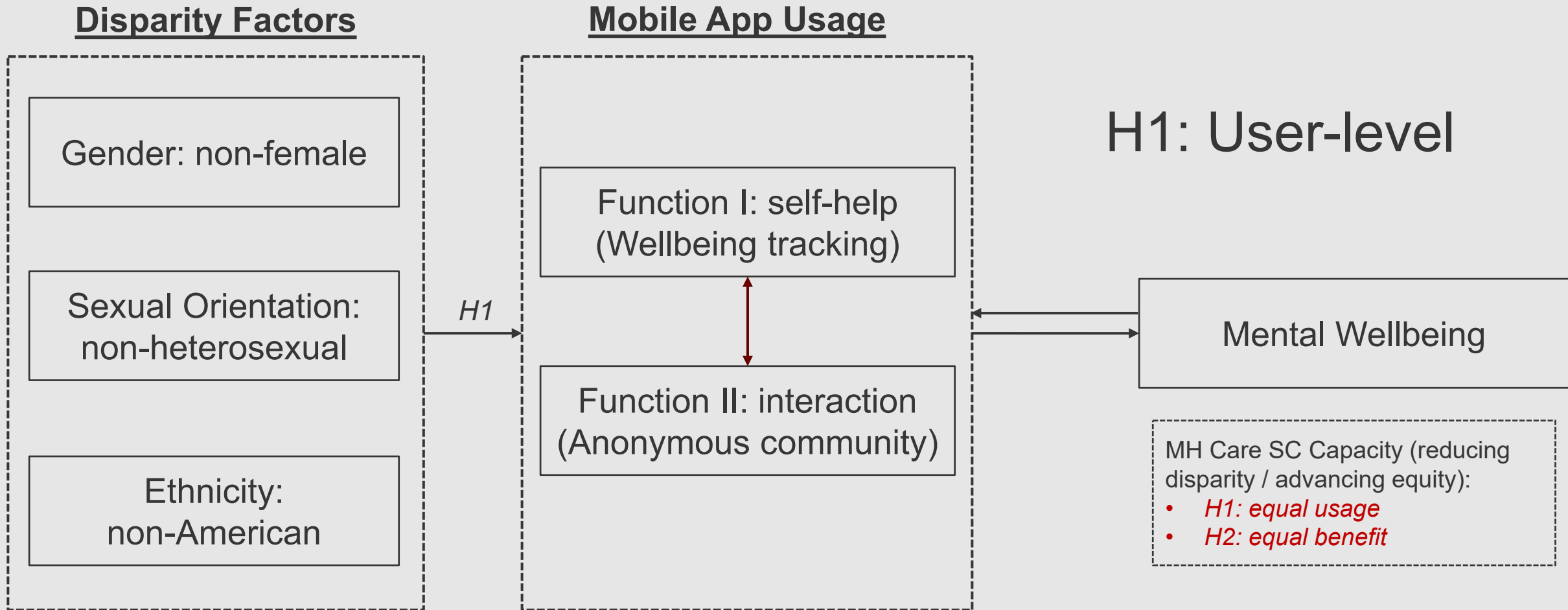
Descriptive Statistics: *usage_community*

<i>usage_community</i>	N	Mean	S.D.	Min	Median	Max
Gender:						
Female	577	13.2825	22.83048	1	5	152
Male	166	11.5	19.01921	1	4	111
Other	46	22.02174	36.03609	1	7.5	152
Not reported	127	9.527559	20.36797	1	3	125
Sexual Orientation:						
Heterosexual	526	11.91065	21.86211	1	4	150
Homosexual	55	13.09091	19.06351	1	4	80
Other	191	15.91623	23.09986	1	7	137
Prefer not to answer	39	13.5641	25.89838	1	5	140
Not reported	103	9.106796	18.89907	1	3	119
Race/Ethnicity:						
American	522	12.35057	20.8813	1	5	152
European	57	11.61404	26.80735	1	3	150
African	11	12.63636	12.66707	2	8	43
Asian	45	14.48889	21.07629	1	6	91
Latino	48	14.04167	30.02974	1	2	136
Multiple	99	16.37374	27.21329	1	5	128
Not reported	134	11.94776	23.11082	1	3	152
Overall:	916	12.87773	22.81559	1	4	152

Descriptive Statistics: *avg_wellbeing*

<i>avg_wellbeing</i>	N	Mean	S.D.	Min	Median	Max
Gender:						
Female	1247	33.74456	25.19411	0	29.04762	100
Male	490	46.36325	27.10469	0	49.17857	100
Other	86	27.6311	20.91424	0	22.14286	82.66138
Not reported	431	33.20717	27.29324	0	26.69841	100
Sexual Orientation:						
Heterosexual	1270	40.67975	26.63925	0	39.82143	100
Homosexual	151	33.71879	24.80907	0	30.13571	100
Other	374	29.31332	22.8594	0	26.20536	88.57143
Prefer not to answer	93	34.1954	25.5603	0	26.69841	100
Not reported	366	28.92855	26.90301	0	19.42857	100
Race/Ethnicity:						
American	1225	37.64543	26.08349	0	34.28571	100
European	215	43.46364	25.08701	0	43	100
African	26	34.49888	26.9944	1.142857	30.14286	93.57143
Asian	105	40.5532	25.64898	0	40.30952	89.71429
Latino	90	27.76239	23.66411	0	24.14286	83.92857
Multiple	177	35.75669	27.60639	0	31.19577	100
Not reported	416	28.94972	26.59963	0	19.9958	100
Overall:	2254	36.15174	26.44776	0	32.30952	100

H1: Equal Usage



H1: Equal Usage

- > Simultaneous equations model (3sls)

$$usage_tracking_i = \alpha_0 + \alpha_1 \underline{usage_community_i} + \alpha_2 \underline{avg_wellbeing_i} + \alpha_3 \underline{notif_tracking_i} + \alpha_4 \ln_tenure_i + \alpha_5 Profile_i + u_i$$

$$usage_community_i = \beta_0 + \beta_1 \underline{usage_tracking_i} + \beta_2 \underline{avg_wellbeing_i} + \beta_3 \underline{notif_community_i} + \beta_4 \ln_tenure_i + \beta_5 Profile_i + v_i$$

$$avg_wellbeing_i = \gamma_0 + \gamma_1 \underline{usage_tracking_i} + \gamma_2 \underline{usage_community_i} + \gamma_3 \underline{inital_wellbeing_i} + \gamma_4 \ln_tenure_i + \gamma_5 Profile_i + w_i$$

Endogenous Var.

Exogenous Var.

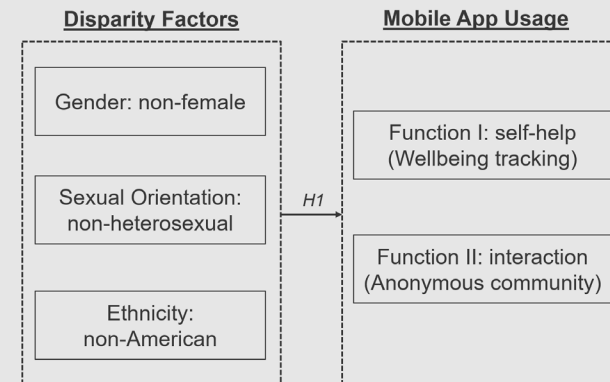
- > However, simultaneous equation model
 - > requires homoscedasticity to be consistent (Cameron&Trivedi, 2010)
 - > treat two usage variables as continuous variables (potentially negative fitted or predictive values)

H1: Exponential Reg. & GMM Estimator

$$usage_tracking_i = \exp(\alpha_0 + \alpha_1 usage_community_i + \alpha_2 avg_wellbeing_i + \alpha_3 nnotif_tracking_i + \alpha_4 \ln_tenure_i + \alpha_5 Profile_i) + u_i$$

$$usage_community_i = \exp(\beta_0 + \beta_1 usage_tracking_i + \beta_2 avg_wellbeing_i + \beta_3 nnotif_community_i + \beta_4 \ln_tenure_i + \beta_5 Profile_i) + v_i$$

- > Exponential regression with instrument variables: *ivpoisson* in Stata 15
 - > NOT Poisson regression
 - > Robust to over-dispersion with robust standard errors (*Wooldridge 2010*)
 - > Use generalized method of moments (GMM) estimators



H1: Exponential Reg. & GMM Estimator

VARIABLES	Model 1 <i>usage_tracking</i>	Model 2 <i>usage_tracking</i>	Model 3 <i>usage_community</i>	Model 4 <i>usage_community</i>
<i>Constant</i>	-0.840(0.415)*	-0.667(0.436)	3.072(0.547)***	3.063(0.891)***
<i>usage_tracking</i>	-	-	0.0357(0.0129)**	0.0681(0.0299)*
<i>nnotif_tracking</i>	0.113(0.0135)***	0.0955(0.0141)***	<i>IV</i>	<i>IV</i>
<i>usage_community</i>	0.0135(0.00151)***	0.0127(0.00143)***	-	-
<i>nnotif_community</i>	<i>IV</i>	<i>IV</i>	0.0126(0.001)***	0.0128(0.001)***
<i>avg_wellbeing</i>	0.00123(0.00156)	0.00163(0.00161)	-0.000215(0.00297)	-0.00314(0.00533)
<i>ln_tenure</i>	0.301(0.0722)***	0.261(0.0768)***	-0.222(0.104)*	-0.296(0.214)
<i>age</i> < 18 or > 24		<i>base group</i>		<i>base group</i>
18~24		0.238(0.0802)**		-0.00361(0.157)
Not reported		0.0102(0.114)		0.604(0.236)*
<i>gender</i> Female		<i>base group</i>		<i>base group</i>
Male		0.0933(0.0998)		-0.382(0.355)
Other		0.415(0.174)*		-1.159(0.900)
Not reported		0.159(0.141)		-0.602(0.240)*
<i>Sexual orientation</i> Heterosexual		<i>base group</i>		<i>base group</i>
Homosexual		0.253(0.167)		-0.444(0.448)
Other		0.175(0.0958)†		0.0699(0.165)
Prefer not to answer		0.170(0.199)		-0.442(0.279)
Not reported		-0.257(0.199)		-0.271(0.331)
<i>Race/Ethnicity</i> American		<i>base group</i>		<i>base group</i>
European		-0.192(0.137)		-0.0658(0.292)
African		-0.174(0.328)		0.894(0.530)†
Asian		-0.0941(0.157)		0.554(0.278)*
Latino		-0.395(0.154)*		0.466(0.327)
Multiple		-0.156(0.112)		0.265(0.225)
Not reported		-0.242(0.190)		0.593(0.360)†
Observations	2,210 ^a	2,210 ^a	901 ^b	901 ^b

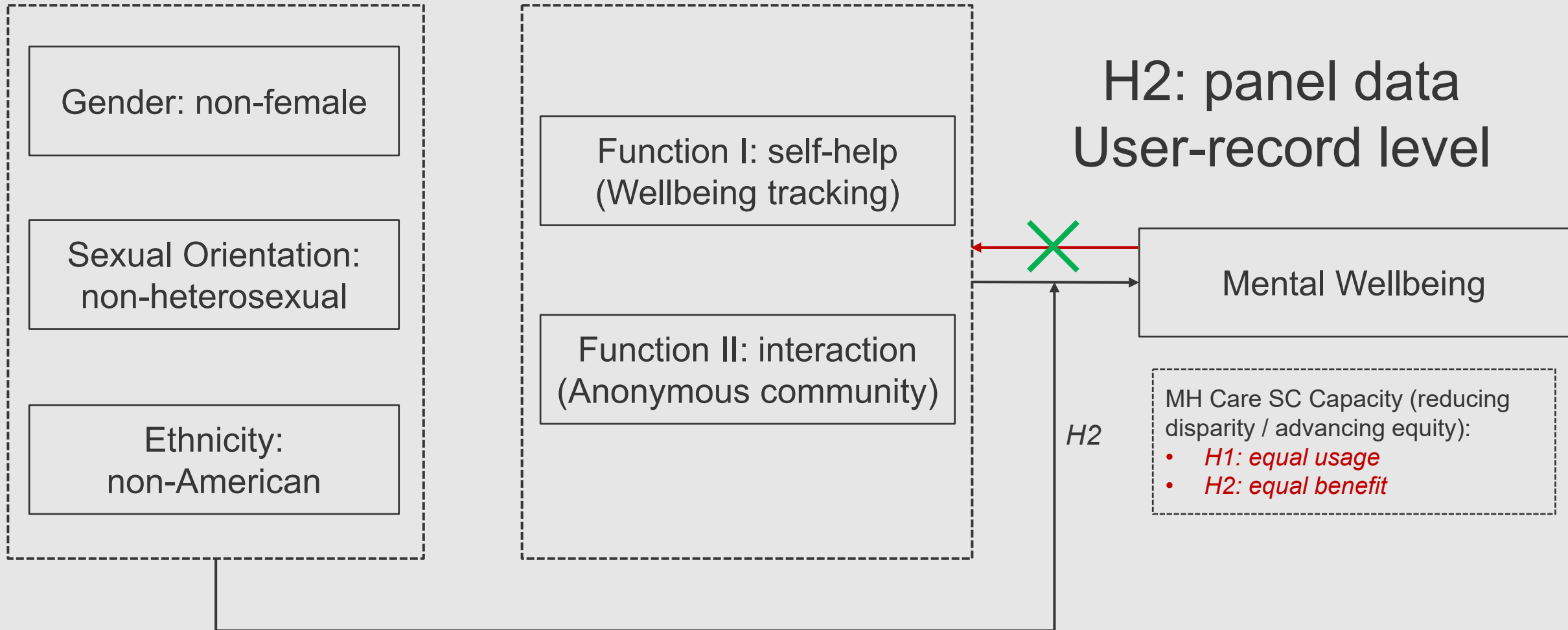
H1 (equal usage) is supported

> Users from underserved population (in terms of gender, sexual orientation and race/ethnicity) **have equal usage of mobile app** as their non-underserved counterparts.

> Robustness check

- > Drop “not reported” users
- > Simultaneous equation model

H2: Equal Benefits

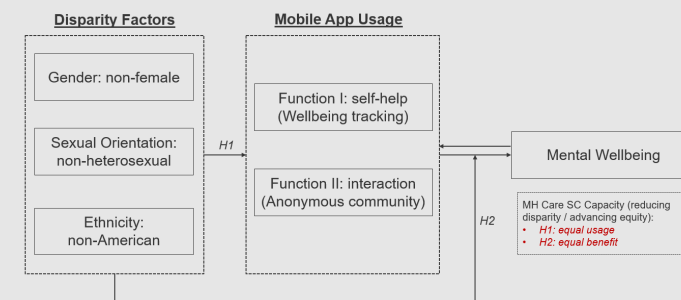


H2: Equal Benefits

- > A panel data analysis with lagged cumulative usage as independent variables

$$\begin{aligned}
 wellbeing_{it} = & \alpha_0 + \alpha_1 usage_tracking_cum_{it} + \alpha_2 usage_community_cum_{it} + \alpha_3 \ln_tenure \\
 & + \alpha_4 usage_tracking_cum_{it} * Profile_i + \alpha_5 usage_community_cum_{it} * Profile_i \\
 & + \alpha_6 year_dummies_{it} + \alpha_7 month_dummies_{it} + c_i + u_{ij}
 \end{aligned}$$

- > Fixed effects vs. random effects
 - > FE: c_i : personality / internet access etc. → usage
 - > FE: allow attrition (unbalanced panel) to be correlated with c_i and all the explanatory variables



H2: FE Model

H2 (equal usage) is partially supported

> In average, the base category user (non 18~24, heterosexual and American female): no significant effect

> Compared with the base category user, these underserved population **benefit more** from using **wellbeing tracking function**:

- > Heterosexual
- > African / Asian / European / Latino

> Compared with the base category user, these underserved population's mental wellbeing **got worse** after participating in the **anonymous peer community**:

- > Other or not reported gender identity
- > African / Asian

> However, for people with potential mental health crisis

VARIABLES	Model 1	Model 2	Model 3	Model 4
	FE	FE	FE (crisis)	FE (non-crisis)
<i>Constant</i>	46.88(4.864)***	40.0(5.110)8***	12.82(10.0)	61.37(5.823)***
<i>ln_tenure</i>	1.703(0.305)***	1.004(0.362)**	0.728(0.50)	1.856(0.437)***
<i>usage_tracking_cum</i>	0.00542(0.0353)	0.00810(0.036)	-0.303(0.1)**	0.140(0.082)+
<i>usage_community_cum</i>	0.000415(0.001)	0.0188(0.020)	0.0468(0.0243)+	-0.00594(0.06)
Interaction with <i>usage_tracking_cum</i>				
<i>Age*usage_tracking_cum</i>		<i>18~24</i>	-0.0647(0.035)+	0.211(0.0995)*
		<i>Not reported</i>	0.576(0.167)***	-0.268(0.461)
<i>Gender*usage_tracking_cum</i>		<i>Male</i>	-0.0474(0.0374)	0.198(0.102)+
<i>Sexual orientation*usage_tracking_cum</i>		<i>Homosexual</i>	0.293(0.0738)***	0.0159(0.0954)
		<i>Prefer not to answer</i>	0.209(0.149)	0.534(0.283)+
<i>Race/Ethnicity*usage_tracking_cum</i>		<i>African</i>	1.508(0.334)***	-0.180(1.672)
		<i>Asian</i>	0.207(0.0866)*	0.0850(0.237)
		<i>European</i>	0.101(0.0441)*	0.270(0.273)
		<i>Latino</i>	0.191(0.0499)***	-0.380(0.392)
		<i>Not reported</i>	-0.0774(0.293)	-0.260(0.141)+
Interaction with <i>usage_community_cum</i>				
<i>Age*usage_community_cum</i>		<i>Not reported</i>	-0.338(0.130)**	-0.0377(0.182)
<i>Gender* usage_community_cum</i>		<i>Male</i>	-0.0163(0.0202)	-0.121(0.0702)+
		<i>Other</i>	-0.453(0.162)**	-0.167(0.199)
		<i>Not reported</i>	-0.370(0.104)***	-0.375(0.139)**
<i>Sexual orientation* usage_community_cum</i>		<i>Homosexual</i>	0.0735(0.0731)	0.120(0.0439)**
<i>Race/Ethnicity* usage_community_cum</i>		<i>African</i>	-0.567(0.107)***	-0.302(0.239)
		<i>Asian</i>	-0.419(0.162)**	-0.301(0.171)+
		<i>European</i>	-0.172(0.241)	-0.369(0.170)*
		<i>Latino</i>	-0.176(0.200)	-0.207(0.233)
		<i>Multiple</i>	0.177(0.0907)+	0.251(0.155)
<i>Year fixed effects</i>	YES	YES	YES	YES
<i>Month fixed effects</i>	YES	YES	YES	YES
<i>Clustered S.E.</i>	YES	YES	YES	YES
<i>Observations</i>	11,524	11,524	4,709	6,815
<i>Within-group R-squared</i>	0.015	0.048	0.060	0.070
<i>Between-group R-squared</i>	0.164	0.115	0.010	0.014
<i>Overall R-squared</i>	0.159	0.116	0.006	0.057
<i>Number of individuals</i>	2,031 ^a	2,031 ^a	1,033 ^b	998 ^c