Journal of Racial and Ethnic Health Disparities (2018) 5:1373–1380
https://doi.org/10.1007/s40615-018-0487-9

A Digital Language Divide? The Relationship between Internet Medication Refills and Medication Adherence among Limited English Proficient (LEP) Patients

Alejandra Casillas[1] · Gerardo Moreno[2] · Jonathan Grotts[1] · Chi-Hong Tseng[1] · Leo S. Morales[3]

Received: 27 August 2017 / Revised: 19 December 2017 / Accepted: 19 March 2018 / Published online: 29 March 2018

Abstract

Background Use of an Internet portal to refill medicines positively affects medication adherence among English-speakers. No prior studies, however, have specifically examined the relationship between Internet refills and medication adherence among patients who are limited English proficient (LEP).

Objectives (1) Examine the relationship between Internet medication refill system use and medication adherence among linguistically diverse patients with chronic conditions and (2) compare this relationship between LEP and English-proficient (EP) patients.

Design, Participants, Measures We analyzed 2013–2014 cross-sectional data from 509 surveyed adults in the Group Health Cooperative. Surveys were merged with plan enrollment, claims data, and electronic medical records. Medication adherence was calculated by the "Continuous Measure of Medication Gaps" (CMG) method. For Internet refill system use, patients were asked, "Have you used the health systems Internet site to refill any medications in the last 12 months?" LEP status was captured in the electronic medical record by a non-English primary language and a claims record of interpreter use in at least one clinical encounter between 2005 and 2012. We used multivariate linear regression models to examine Internet refill system use and medication adherence and compared the association between LEP and EP patients.

Results Three hundred eighty-four patients (75%) had a calculable CMG: 134 EP and 250 LEP in the adherence analyses. In unadjusted analyses, LEP patients had lower use of the Internet refill system ($p < .001$) and lower adherence versus the EP group ($p < .001$). In multivariate analyses, LEP status ($\beta = -0.022$, $p = .047$) was negatively associated with adherence, while use of the Internet refill system ($\beta = 0.030$, $p = .002$) was positively associated. In stratified models, use of Internet refills was positively associated with adherence, even when examining LEP ($\beta = 0.029$, $p = .003$) and EP patients ($\beta = 0.027$, $p = .049$) separately.

Conclusions These findings suggest that LEP patients may be under-utilizing a beneficial Internet tool. Should our healthcare systems fail to ensure that LEP patients have full and meaningful access to Internet patient portals, we risk worsening healthcare disparities.

Keywords Limited English proficiency · Digital divide · Health disparities · Patient portal · Medication adherence

Background

The crossover between technology and healthcare services offers an innovative and efficient way to provide medical care tailored to the needs and preferences of patients, streamlining the process of medical care. As an example, online patient portals, tethered to the electronic medical record (EMR), are a new standard for communication and service in the healthcare industry. These portals allow patients to contact provider teams, schedule visits, view visit summaries and medical record information, check test results, access health education, and manage medication prescriptions and refills from the convenience of their Internet-connected device.

✉ Alejandra Casillas
acasillas@mednet.ucla.edu

[1] Division of General Internal Medicine and Health Services Research, Department of Medicine, UCLA David Geffen School of Medicine, 911 Broxton Avenue, Los Angeles, CA 90024, USA

[2] Department of Family Medicine, UCLA David Geffen School of Medicine, Los Angeles, CA, USA

[3] Center for Health Equity, Diversity and Inclusion, University of Washington School of Medicine, Seattle, WA, USA

After almost two decades since the implementation of portals in early adopter systems (i.e., Kaiser Permanente, Group Health), the results are promising [1–3]. Health benefits associated with portal use include glycemic control among diabetics, cholesterol reduction (adherence to statins), and improved blood-pressure management [3].

However, recent evidence demonstrates that patients with communication barriers are less likely to access a variety of digital (Internet-connected) tools like the patient portal—as these are almost exclusively designed and implemented with a "mainstream" English-speaking population in mind. It is well documented that digital divides exist in the general US population by race/ethnicity, income, older age, educational attainment, rural residence, and health literacy (which also encompasses English proficiency) [4–8]. The digital divide reflects the structural barriers to digital access disproportionately affecting these vulnerable groups: (1) access to the Internet; (2) knowledge on how to use the Internet; (3) access to Internet-connected devices such as computers, tablets, and/or phones; and (4) knowledge on how to use Internet-connected devices [4–8]. But, in addition, system-design factors such as ease of use and, for example, availability of digital interfaces in multiple languages, affect a patient's ability to uptake and effectively engage with technology tools in the healthcare system. While non-white race/ethnicity was the strongest negative predictor of patient portal registration in the well-known Kaiser system, uptake further decreased for Spanish-speaking Latinos and minority older adults who were non-English speaking [7]. These findings suggest that the same subgroups of vulnerable populations who have traditionally struggled to access medical care in the USA and have faced stark health disparities compared to the general population, do not utilize technological advancements that could provide efficient disease management—which include remote medication refills through an Internet patient portal [8–11].

One group that is notably left behind in this divide are the 22.3 million people in the USA who are limited English proficient (LEP)—defined as a "limited ability to listen, speak, read, and write in English" and/or "self-rated English ability of less than "very well." [12] Patients with limited English proficiency and chronic disease are at increased risk for poor medication control and non-adherence, and yet do not utilize beneficial healthcare tools, like medication refill access through a portal [12–14]. Prior research examined the relationship between English proficiency and use of Internet medication refill systems and found that only 21% of LEP patients with chronic illness used the online service, compared to 53% of English-proficient patients [6]. This discrepancy is not surprising, given that the majority of refill services through an online patient portal are exclusively delivered in English—but also because LEP patients are affected by many of the aforementioned sociodemographic factors that exacerbate the digital divide (lower education, lower income, foreign-born status, lower literacy levels, and decreased access to technology) [6.]

This is problematic, as patients who do use the patient portal for medication refills demonstrate higher rates of medication adherence [2]. And despite the known digital divide, a handful of studies show that racial/ethnic minorities and other underserved populations directly benefit (improvements in adherence) from the refill function through an online patient portal, when they utilize it [7, 15]. However, these studies are nonetheless focused on English-speaking patients. No prior studies, that we are aware of, have examined the association between remote Internet refills through a patient portal and medication adherence, among LEP patients—likely because the majority of patient portals are English only. This still begs the question as to how LEP populations are affected by the current, albeit imperfect, portal services that do exist.

The following study addresses this specific gap with regard to medication adherence through the following aims: (1) to examine the relationship between use of an Internet medication refill system and medication adherence among linguistically diverse patients with chronic conditions and (2) to compare this relationship between LEP and English-proficient (EP) patients.

Methods

Setting The data for this study was collected from 509 adults with chronic conditions in the Group Health Cooperative (GHC), a nonprofit healthcare system serving approximately 600,000 enrollees in the State of Washington. GHC is an early adopter of the EMR—an integrated patient portal (English-only) is available since 2003.

The study used four sources of data: telephone survey, health plan enrollment, inpatient and outpatient claims data (includes interpreter utilization), and electronic medical records linked to respondents. The Institutional Review Boards at GHC and University of California, Los Angeles, approved this study. The datasets generated/analyzed during the current study are not publicly available due to ongoing analyses but are available from the corresponding author on reasonable request.

Participants A telephone survey about chronic conditions and medication management was conducted between September 2013 and January 2014 in six languages. Inclusion criteria were as follows:

1. 18 years or older
2. English, Spanish, Korean, Cantonese, Mandarin or Vietnamese-speaking (six most common languages at Group Health); for patients whose primary language was not English, an additional inclusion criterion was

the use of an interpreter during at least one clinical visit between 2005 and 2012
3. Continuous enrollment in Group Health integrated group practice 6 months prior to the beginning of the survey
4. ICD-9 diagnosis of diabetes mellitus (DM), hypertension (HTN), and/or hyperlipidemia (HL)
5. At least one outpatient clinic visit (not urgent care or emergency) within the health system during the last 6 months

Exclusion criteria were diagnoses of Alzheimer's disease, dementia, renal failure, pregnancy in prior 12 months or an admission to a hospice, hospital, or SNF in prior 12 months. The survey population was a subset of patients randomly selected from a larger cohort of eligible patients with DM, HTN, or HL—representative of the GHC population. A total of 1490 participants (493 EP and 997 LEP) were invited to complete the survey. LEP patients were oversampled to attain representation by each language group, as reflected in the GHC [6].

Primary Outcome, Medication Adherence Medication adherence was measured using the well-validated continuous measure of medication gaps method (CMG) [16, 17]. CMG is an objective measure of adherence that uses pharmacy filling of medications to measure gaps in patients' available supply of medications. The CMG adherence measure was based on at least two pharmacy fills on an existing prescription over a 12-month period preceding the survey (medication possession ratio). The CMG percentage is calculated as the number of days a patient had medication available (based on fills) divided by the number of days the patient should have been on medication. We report the proportion of days covered. This CMG method has been well-validated against electronic pill cap monitoring, serum/urine drug levels, physiological drug effects, change in clinical control (such as blood pressure measures), co-morbidity, and cost [16, 18–20]. In addition to health systems like the Veterans Administration (VA) and Kaiser Permanente, CMG has also demonstrated acceptable inclusiveness and validity in diverse, low-income safety net populations [21]. This analysis is limited to respondents who had a calculable adherence measure.

CMG adherence for three medication groups (typically treating the three chronic conditions of patients in the study) was examined: (1) oral hypoglycemics, (2) anti-hypertensives, and (3) lipid-lowering drugs. Adherence was defined as average adherence for each prescribed medication, weighted by the number of days within each observation window for each medication (i.e., time between first and last fill). The four adherence measures are: "overall adherence" (adherence rate across all medications) + an adherence measure rate for medication(s) specific to the aforementioned groups "DM-med adherence" (oral hypoglycemics), (2) "HTN-med adherence" (anti-hypertensives), and "HL-med adherence" (lipid-lowering drugs). In addition, dichotomous versions of all CMG adherence measures were created to describe patients as "highly adherent" or "poorly adherent." Patients whose reverse-coded CMGs were less than 80% (i.e., gap in therapy>20%) were classified as "poorly adherent," whereas those greater than 80% were classified as "highly adherent," a determination that is based on prior studies [16–20].

Predictor Variables Patients were provided with a brief description of the Internet refill system and then asked, "Have you used the health systems Internet site to refill any medications in the last 12 months?" Respondents who answered "do not know" ($n = 14$ for Internet) were categorized as "no." LEP status was captured by electronic medical record data—patient self-identification of a primary language other than English, plus a claims record of use of an interpreter.

Other Measures Other survey measures were age, gender, marital status, race/ethnicity, language/dialect, education, household income, years in the USA for foreign-born patients, Medicare/Medicaid insurance status, health status, chronic condition, number of prescribed medications, and social support (eight questions gauging resources; final score of 0 "no support" to 40 "always supported"). Missing responses were less than 1% for all the variables except the income question, where 4.9% refused to answer and 8.6% answered "do not know."

Analysis All statistical analyses were conducted using STATA version 14.2 (College Station, TX) software, and a p value of < 0.05 was used to determine statistical significance. We calculated inverse probability weights (IPWs) to account for differential survey response from study participants by age group and language. The IPWs were applied in the analysis to mitigate bias incurred by survey non-response. The probability modeling using IPWs for this cross-sectional survey has been described previously [6].

Univariate summary statistics, bivariate chi-square analysis on categorical variables, and t tests and one-way analysis of variance on continuous variables were done for cases with calculable CMGs. We compared these across LEP and EP cases. We used the literature on adherence and limited English proficiency and significant associations in bivariate analyses to determine the final set of covariates, given the sample size. We used multivariate linear regression models to examine the adjusted effects of use of the Internet refill system on overall medication adherence and compared this association between LEP and EP patients using stratified models. Final models were adjusted for age, gender, education, insurance, chronic conditions, and number of medications.

Results

A total of 509 patients completed the survey. The overall response rate for the survey was 35.5% ($n = 509$; 34.5% LEP, $n = 328$; and 37.4% EP, $n = 181$). This analysis is limited to the 384/509 (75%) who had a calculable CMG adherence measure—134/181 (74%) EP and 250/328 (76%) LEP. Respondents who had calculable CMGs were older (66 vs. 63 years, $p = 0.001$), on more prescribed medications (6 vs. 3, $p < 0.001$), and were more likely to be on Medicare/Medicaid insurance (31 vs. 18%, $p < 0.001$) versus those who did not have a CMG adherence measure ($n = 125$) (data not shown). There were no other significant differences across all characteristics, even within the two language proficiency groups.

The weighted distributions and means for patient demographics and health characteristics for the 384 participants with a CMG adherence measure, by LEP status, are shown in Table 1. Compared with EP respondents, LEP individuals were younger, more likely to be married, less college/university educated, and had lower self-rated health status. The LEP group had a higher percentage of diabetes but no difference in hypertension or hyperlipidemia diagnoses. LEP patients also had a lower number of prescribed medications and a lower social support score versus the EP patients. Notably, LEP patients had significantly lower use of Internet remote refill systems compared to the EP patients (22 vs. 56%, $p < 0.001$).

Among all patients (Table 2), overall medication adherence was high, and LEP patients had a lower overall adherence rate versus the EP group (0.901 vs. 0.938, $p < 0.001$) and a lower percentage of being "highly adherent," defined as adherence > 0.80 (87 vs. 96%, $p < 0.001$). Furthermore, LEP respondents had lower medication adherence and lower percentages of highly adherent for all three condition-specific medication categories.

The multivariate linear regression analysis for overall adherence among all patients and in stratified models (LEP alone, EP alone) is shown in Table 3. LEP status ($\beta = -0.022$, $p = .047$) and a diagnosis of hyperlipidemia ($\beta = -0.025$, $p = .008$) were negatively associated with overall adherence. Use of the Internet refill system ($\beta = 0.030$, $p = .002$), Medicare or Medicaid insurance ($\beta = 0.030$, $p = .007$), and a college/university education (or higher level) ($\beta = 0.0029$, $p = .029$) were positively associated with adherence. The interaction term (LEP*Internet refill use) was not significant ($p = 0.89$). In stratified models, use of remote Internet refills was positively associated with adherence, even when examining LEP ($\beta = 0.029$, $p = .003$) and EP patients ($\beta = 0.027$, $p = .049$) separately. In the EP model of overall adherence, Medicare/Medicaid insurance status was positively associated ($\beta = 0.040$, $p = .01$), while among LEP patients, hyperlipidemia was negatively associated with adherence ($\beta = -0.035$, $p = .004$).

Although the sensitivity tests are not shown, we also compared LEP Internet refill users and LEP non-users across all variables used in this analysis and across some survey questions related to English language understanding. There were no significant differences for these, within the LEP group, across Internet refill user status. For the same comparison of study variables among the EP patients alone, we observed that Internet refill users were significantly younger and had higher percentages of patients with household income > 75 K, and also a university/college level education.

Discussion

We found that the use of remote medication refills through an Internet portal was independently and significantly associated with higher medication adherence in both EP and LEP patients. Compared to EP patients, LEP status was associated with lower use of Internet portal refills and decreased medication adherence even after adjusting for covariates. We add to the literature by demonstrating that linguistically diverse patients are under-utilizing a portal tool that is positively associated with medication adherence. Our results extend previous studies that focused on race/ethnicity (but not language) and the relationship between Internet portal medication refills and medication adherence [2, 5, 7, 15].

Some strengths of this study include the linguistically diverse cohort and the use of the well-validated CMG to measure adherence. CMG does not measure actual medication taken—it is based on time only, which is a known limit of this measure. And while only 75% of respondents had a calculable CMG, this level is equivalent and/or higher than the CMG calculability rates achieved in other comparable populations [21]. Another related limitation is that CMG was calculated for three primary groups of ongoing medication prescriptions and did not include medications for other common chronic conditions (such as COPD or asthma) or adherence to new prescriptions. However, the study intentionally focused on patients with one of three chronic medical conditions (DM, HTN, HL) that would probably be treated with the medication classes included. There were adequate rates of calculable CMGs across patients with each of the three ICD-9 diagnoses, confirming that no group of patients were "left out": 82% of patients with a DM diagnosis, 72% of patients with HL patients, and 85% with HTN patients had a calculable CMG for at least one medication. It is also possible that our adherence measure did not capture cases of patients taking the aforementioned medication groups through another health system or in another pharmacy by paying "cash only." This specific limitation may be better addressed in future studies by also asking patients if they get any medications outside of their primary health system.

Table 1 Weighted percentages and means for patient characteristics by English proficiency status among respondents with a calculable CMG ($n = 384$)

Variable	English proficient ($n = 134$) %	Limited English proficient ($n = 250$) %	p value
*Age, mean years (SD)**	68.4 (11.75)	63.12 (10.14)	< 0.001
Female	58	63	0.503
*Married**	67	76	0.007
Household income*			< 0.001
Less than $25,000	4	31	
$25,000–$49,999	28	27	
$50,000–$74,999	27	20	
> $75,000	33	8	
Don't know/refused	8	15	
Education*			< 0.001
HS/prep school or less	24	71	
Trade/vocational school	5	7	
University/college	67	18	
Other	3	3	
Don't know/refused	0	1	
Language			n/a
Cantonese	0	15	
English	100	0	
Korean	0	24	
Mandarin	0	11	
Spanish	0	20	
Vietnamese	0	30	
Race/ethnicity*			< 0.001
White	93	12	
Black	2	1	
Chinese	2	27	
Korean	0	25	
Vietnamese	0	27	
Other	2	2	
Latino	0	17	
Years in the USA			n/a
1–10 years	0	6	
11–15 years	0	8	
15+ years	100	86	
Health status*			< 0.001
Excellent	12	3	
Very good	38	11	
Good	38	36	
Fair	10	43	
Poor	2	7	
Don't know	0	0	
Refused	0	0	
ICD-9 diagnoses			
DM	30	45	0.027
HL	68	61	0.267
HTN	85	82	0.196
Medicare and/or Medicaid	31	26	0.275
# of prescribed medications, mean # of medications (SD)*	7.53 (4.6)	6.02 (3.94)	0.001
*Social support score, mean score (SD)**	32.77 (8.85)	26.98 (10.59)	< 0.001
*Used Internet medication refill**	56	22	< 0.001

* p-value less than or equal to 0.05 is statistically signficant

Table 2 Adherence outcomes across English proficiency status

CMG adherence	English proficient ($n = 134$)	Limited English proficient ($n = 250$)	
Overall adherence			
CMG Mean (SD)*	0.938 (0.069)	0.901 (0.091)	< 0.001
% with CMG > = 0.8*	96%	87%	< 0.001
HL-med adherence			
CMG Mean (SD)*	0.927 (0.097)	0.893 (0.101)	0.024
% with CMG HL > = 0.8*	89%	83%	< 0.001
DM-med adherence			
CMG Mean (SD)	0.932 (0.052)	0.904 (0.078)	0.127
% with CMG DM > = 0.8*	95%	89%	0.035
HTN-med adherence			
CMG Mean (SD)*	0.947 (0.051)	0.907 (0.092)	< 0.001
% with CMG HTN > = 0.8*	97%	88%	< 0.001

* p-value less than or equal to 0.05 is statistically signficant

The Group Health Internet portal was offered in English during the time of the study, and so, even LEP patients utilized the refill system in English. This poses the question as to whether LEP patients using the Internet refill system had better English proficiency versus non-users or were different in any other significant ways. The telephone survey administered to all patients included questions from the Consumer Assessment of Healthcare Providers and Systems Survey (CAHPS), some of which are related to English understanding/communication. As a sensitivity test, we queried whether English language variability as assessed by these questions, accounted for differences in portal use among the

Table 3 Multivariate regression analysis of overall adherence and Internet medication refills among the $n = 384$ patients with calculable CMGs, and in stratified models (EP vs. LEP)

Predictors	All patients β	EP alone β	LEP alone β
LEP (*Ref.* EP)	− 0.022*	–	–
	p = 0.047		
Internet refill use (*Ref.* no. use)	0.030*	0.027*	0.029*
	p = 0.002	*p = 0.05*	*p = 0.032*
Age	0.0005	0.0008	0.0012
	p = 0.275	p = 0.21	p = 0.092
Female (*Ref.* male)	0.006	0.003	0.0127
	p = 0.49	p = 0.82	p = 0.28
Education	− 0.054, 0.0029,	− 0.048, 0.0071,	− 0.064, 0.004
(*Ref.* ≤HS/prep. school)	− 0.0079, − 0.029*	0.04, n/a	− 0.02, − 0.003*
Trade school, College, Other, Unknown	*p = 0.029*	p = 0.15	p = 0.06
Medicare/Medicaid (*Ref.* other insurance)	0.030*	0.0404*	0.024
	p = 0.007	*p = 0.01*	p = 0.124
Diabetes (DM) (*Ref.* no. DM)	0.0062	0.0065	0.006
	p = 0.50	p = 0.64	p = 0.63
Hyperlipidemia (HL) (*Ref.* no. HL)	−0.025*	0.0037	−0.035*
	p = 0.008	p = 0.79	*p = 0.004*
Hypertension (HTN) (*Ref.* no. HTN)	0.011	0.019	0.011
	p = 0.36	p = 0.31	p = 0.46
# of prescribed medications	0.0004	− 0.0012	0.002
	p = 0.69	p = 0.41	p = 0.55
Adjusted R^2	0.141	0.111	0.135

* p-value less than or equal to 0.05 is statistically signficant

LEP patients. We found no such differences between LEP Internet refill users and LEP non-users. Among the EP Internet refill users, sociodemographic variables such as younger age, higher education, and income level were more predictive of Internet refill use (as expected). Interestingly enough, this was not the case among LEP patients. These findings highlight that there may be very different predictive factors for uptake and use of these Internet portals for LEP patients and should thus be investigated more thoroughly. Future work must examine the related factors (other than English proficiency), such as cultural differences, which account for the differences in portal uptake between English-speaking and non-English-speaking patients. Additional studies among diverse populations should also be conducted with multilingual portal options, to better gage the effect of these tools in the patient's preferred real-world setting.

The cross-sectional design does not allow for inference of casual relationships. Given that 509 of 1490 invited patients completed the survey, this does limit the representativeness of the final analytic sample. In addition, we used self-reports for certain measures, which are subject to recall bias and socially desirable answers. Of note, our main predictor (Internet portal use for refills) was self-report and so does not account for actual use. Furthermore, we did not distinguish between frequent or occasional use of the Internet patient portal and its impact on medication adherence. Prior studies have shown that there may be a dose response effect between Internet portal medication refills and medication adherence [2]. Our results may not generalize to all patients with LEP, those that speak other languages, or other healthcare systems.

Finally, adherence rates for ongoing prescriptions were good across all patients in the analysis—and these levels are similar to adherence rates observed for patients in comparable settings like Kaiser Permanente [2]. The important finding, nonetheless, is that a medication adherence rate gap exists between LEP and EP patients, even in a population that has access to high quality of health care. It is likely that linguistic disparities in use of Internet refill systems and adherence are more pronounced in underserved settings (outside of systems like GHC and KP). The study also took place before the full expansion of the Affordable Care Act (ACA), as large groups of vulnerable populations came under commercial insurance plans like GHC and KP. Therefore, examining the medication adherence gaps in LEP populations today in these commercial systems, and the effect of Internet patient portal use, is necessary, as these populations are insured.

These findings suggest that LEP patients with chronic conditions are at an increased risk of sub-optimal adherence and are under-utilizing an Internet portal tool that is significantly associated with better medication adherence. The adoption of digital technology is accelerating rapidly, and the Internet has become a now ubiquitous interface for healthcare-related transactions and communication. Should our healthcare system fail to provide LEP patients with the structural access, user-friendly and culturally appropriate digital interfaces, knowledge, and the confidence to digitally access services through an Internet portal, we face the risk of widening existing healthcare gaps among these already-vulnerable populations.

Acknowledgements Contributors: Authors listed, no others.

Prior Presentations: Casillas A, Moreno G, Tseng CH, Grotts J, and L Morales. A digital language divide? The relationship between Internet medication fills and medication adherence among Limited English Proficient patients. Oral Research Presentation. Society of General Internal Medicine Annual Meeting. April 2017 in Washington DC.

Funding This research was supported by R01MD006185 (PI: Morales). Alejandra Casillas MD, MSHS, also received support from the University of California, Los Angeles (UCLA) and Charles Drew University (CDU), resource Centers for Minority Aging Research Center for Health Improvement of Minority Elderly (RCMAR/CHIME) under the NIH/NIA Grant P30-AG021684, and from the UCLA Clinical and Translational Science Institute (CTSI) under the NIH/NCATS Grant Number UL1R001881. The contents of this manuscript are solely the responsibility of the authors and do not necessarily represent the views of the NIH.

Compliance with Ethical Standards

Conflicts of Interest The authors declare that they have no conflict of interest.

References

1. Halamka JD, Mandl KD, Tang PC. Early experiences with personal health records. Journal of the American medical informatics association. J Am Med Inform Assoc. 2008;15:1–7.
2. Sarkar U, Lyles CR, Parker MM, Allen J, Nguyen R, Moffet HH, et al. Use of the refill function through an online patient portal is associated with improved adherence to statins in an integrated health system. Med Care. 2014;52:194–201.
3. Zhou YY, Kanter MH, Garrido T. Improved quality at Kaiser Permanente through e-mail between physicians and patients. Health Aff (Millwood). 2010;29:1370–5.
4. Gordon NP, Hornbrook MC. Differences in access to and preferences for using patient portals and other eHealth technologies based on race, ethnicity, and age: a database and survey study of seniors in a large health plan. J Med Internet Res. 2016;18:e50.
5. Roblin DW, Houston TK, Allison JJ, Joski PJ, Becker ER. Disparities in use of a personal health record in a managed care organization. J Am Med Inform Assoc. 2009;16:683–9.
6. Moreno G, Lin EH, Chang E, Johnson RL, Berthoud H, Solomon CC, et al. Disparities in the use of internet and telephone medication refills among linguistically diverse patients. J Gen Intern Med. 2016;31:282–8.
7. Garrido T, Kanter MH, Meng D, Turley M, Wang J, Valerie S, Scott L. Race/ethnicity, personal health record access, and quality of care. Am J Manag Care 2015; e103–e113.
8. The Joint Center Report, April 2012. Minorities, mobile broadband and the management of chronic diseases. Available at: http://jointcenter.org/sites/default/files/Minorities%20Mobile%20Broadband%20and%20the%20Management%20of%20Chronic%20Diseases_0.pdf. Accessed August 9, 2016.
9. Lyles CR, Allen JY, Poole D, Tieu L, Kanter MH, Garrido T. "I want to keep the personal relationship with my doctor":

understanding barriers to portal use among African Americans and Latinos. J Med Internet Res. 2016;18:e263.
10. Tieu L, Sarkar U, Schillinger D, Ralston JD, Ratanawongsa N, Pasick R, et al. Barriers and facilitators to online portal use among patients and caregivers in a safety net health care system: a qualitative study. J Med Internet Res. 2015;17:e275.
11. Schickedanz A, Huang D, Lopez A, Cheung E, Lyles CR, Bodenheimer T, et al. Access, interest, and attitudes toward electronic communication for health care among patients in the medical safety net. J Gen Intern Med. 2013;28:914–20.
12. Shin HB, Bruno R. Language use and English speaking ability: census 2000 brief. Washington DC: US Census Bureau; 2003. Available at: http://www.census.gov/prod/2003pubs/c2kbr-29.pdf. Accessed March 15, 2017
13. Wilson E, Chen AH, Grumbach K, Wang F, Fernandez A. Effects of limited English proficiency and physician language on health care comprehension. J Gen Intern Med. 2005;20:800–6.
14. Karliner LS, Auerbach A, Napoles A, Schillinger D, Nickleach D, Perez-Stable EJ. Language barriers and understanding of hospital discharge instructions. Med Care. 2012;50:283–9.
15. Lyles CR, Sarkar U, Schillinger D, Ralston JD, Allen JY, Nguyen R, et al. Refilling medications through an online patient portal: consistent improvements in adherence across racial/ethnic groups. J Am Med Inform Assoc. 2016;23:e28–33.
16. Steiner JF, Prochazka AV. The assessment of refill compliance using pharmacy records: methods, validity, and applications. J Clin Epidemiol. 1997;50:105–16.
17. Steiner JF, Koepsell TD, Fihn SD, Inui TS. A general method of compliance assessment using centralized pharmacy records: description and validation. Med Care. 1988;26:814–23.
18. Karter AJ, Parker MM, Moffet HH, Ahmed AT, Schmittdiel JA, Selby JV. New prescription medication gaps: a comprehensive measure of adherence to new prescriptions. Health Serv Res. 2009;44:1640–61.
19. Choo PW, Rand CS, Inui TS, Lee MLT, Cain E, Cordeiro-Breault M, et al. Validation of patient reports, automated pharmacy records, and pill counts with electronic monitoring of adherence to antihypertensive therapy. Med Care. 1999;37:846–57.
20. Nau DP, Steinke DT, Williams LK, Austin R, Lafata JE, Divine G, et al. Adherence analysis using visual analog scale versus claims-based estimation. Ann Pharmacother. 2007;41:1792–7.
21. Ratanawongsa N, Karter AJ, Quan J, Parker MM, Handley M, Sarkar U, et al. Reach and validity of an objective medication adherence measure among safety net health plan members with diabetes: a cross-sectional study. J Manag Care Spec Pharm. 2015;21:688–98.