

Research article

Characteristics of electronic patient-provider messaging system utilisation in an urban health care organisation

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ABSTRACT

Introduction Research suggests that electronic messaging can improve patient engagement. Studies indicate that a ‘digital divide’ may exist, where certain patient populations may be using electronic messaging less frequently. This study aims to determine which patient characteristics are associated with different levels of usage of an electronic patient-provider messaging system in a diverse urban population.

Methods Cross-sectional electronic health record data were extracted for patients 10 years of age or older who live in New York City and who visited a set of clinics between 1 July 2011 and 30 June 2012. Regression analyses determined which participant characteristics were associated with the sending of electronic messages.

Results Older, female, English-speaking participants of white race who received more messages, had any diagnoses, more office visits and a provider who sent messages were more likely to send more messages. Non-Millennial, non-white participants who received fewer messages, had more office visits, any diagnoses, a provider who saw fewer patients with patient portal accounts, lived in a low socio-economic status neighbourhood, and did not have private insurance were more likely to send zero messages.

Conclusion This study found significant differences in electronic messaging usage based on demographic, socioeconomic and health-related patient characteristics. Future studies are needed to support these results and determine the causes of observed associations.

Keywords: comorbidities, health information technology (HIT), health records, internet, medical informatics, personal health care disparities, primary health care, urban health services

INTRODUCTION

Since the passage of the 2009 Health Information Technology for Economic and Clinical Health (HITECH) Act in the United States, interest in health information technology (HIT) has grown.¹ Studies have indicated that the use of electronic health records (EHRs) may lead to improvements in operational efficiency and patient outcomes.^{2,3} EHR systems are also expanding to include online portals that allow patients to perform actions, such as scheduling office visits and exchanging electronic messages with health care providers. Certain patient populations are less likely to use electronic systems and this 'digital divide' could bar them from realizing the benefits that electronic systems could provide.^{4,5} Research shows that patients are less likely to sign up for patient portals due to racial disparities,⁶ and that older people and people with low socioeconomic status are less likely to use the Internet⁷ and Web-based programs.^{5,8,9}

Studies suggest that interventions using electronic messaging may improve patient engagement with their providers and adherence to treatment.^{10–13} Pursuant to these claims, provisions of the HITECH Act specifically incentivize providers' usage of electronic messaging.¹⁴ Health care providers that work with disadvantaged populations or populations with low-computer literacy may struggle to meet current or future messaging requirements. A recent survey of patients visiting six health care organisations in San Francisco found that, while a majority of respondents expressed interest in using e-mail to communicate with health care providers, few had actually done so.¹⁵ Understanding variation in messaging usage between different patient populations could help health care organisations target promotional initiatives to improve adoption of messaging functionality. Few studies have specifically studied the characteristics of patients who use electronic patient-provider messaging systems and current studies lack diverse, urban populations.^{16,17} This study helps to fill these gaps by investigating the messaging usage of a demographically and socioeconomically diverse population of patients in New York City.

METHODS

This study was conducted at a Federally Qualified Health Center (FQHC) in New York City. The FQHC uses an EpicCare EHR system (Epic Systems, Verona, WI) with an associated patient portal called MyChart that allows patients to exchange electronic messages with their health care providers. A retrospective cross-sectional study was performed using data recorded in the FQHC's EHR system between 1 July 2011 and 6 June 2012.

Initial analyses included 42,317 patients who resided in New York City and who had at least one clinical visit at the FQHC within the defined time period. The data set is restricted to patients age 10 or older since that is the minimum age at which one can sign up for MyChart at this FQHC. A patient was deemed to be a New York City resident if their recorded ZIP code was in a New York City neighbourhood as

defined by the New York State Department of Health.¹⁸ From this population, we defined a subpopulation of 7653 (18.08% of the sample) patients who had either activated a MyChart account before 1 January 2012 or deactivated their account after that date, meaning that they had an active account for six contiguous months during the period. These patients were considered to be 'MyChart users'. The outcome of interest was the number of messages a patient sent within the defined time frame.

We considered a number of demographic, socioeconomic and clinical variables that may predict messaging usage, based on previous research of patient portal usage.^{6,16} From the EHR we extracted age, gender, race and ethnicity, language preference, insurance status, number of office visits during the year, ZIP code and clinical diagnoses for the following chronic conditions: diabetes, hypertension, hyperlipidaemia, depression, congestive heart failure, asthma, drug abuse, alcoholism and HIV. Age was split into categories based on generation, which has previously been used to characterise Internet usage.^{9,19,20} People were categorised into the G.I. Generation (born before 1937), Silent Generation (born 1937–1945), Older Boomers (1946–1954), Younger Boomers (1955–1964), Generation X (1965–1976), Millennials (1977–1992) and the youngest generation (born after 1992).¹⁹ Race and ethnicity were routinely collected in the EHR using the categories introduced in the 2000 US Census and were analysed separately and in aggregate race/ethnicity categorisations. Insurance status was categorized as 'private', 'public' or 'uninsured'. The number of office visits was categorized into tertiles. The diagnoses listed above have been investigated in previous studies of messaging usage^{5,6} and were investigated separately and in aggregate counts of the total number of diagnoses a patient had.

We used data in the five-year estimates from the 2011 American Community Survey (ACS) to classify patients based on socioeconomic factors.²¹ Neighbourhood data that were collected by the ACS at the ZIP code tabulation area (ZCTA) level as defined by the US Census Bureau were mapped to patients using a ZCTA to ZIP code crosswalk provided by the UDS Mapper.²² We considered median household income, percentage of people below the poverty level, percentage of people who are high school graduates, percentage of people who have bachelor's degrees, and the percentage of people who are unemployed.

For each provider at the FQHC, we collected whether or not they sent any messages over the year period and the percentage of patients they saw over the year who had MyChart accounts (the 'MyChart patient ratio'), which was categorized into tertiles, as measures of a provider's affinity for using MyChart. These provider characteristics were attributed to patients based on which provider the patient saw most often throughout the year period (the 'most-seen provider').

Initial analyses used Pearson χ^2 tests to compare demographic characteristics between people who did and did not use MyChart. Subsequent analyses focused on the subgroup of MyChart users and investigated the number of messages

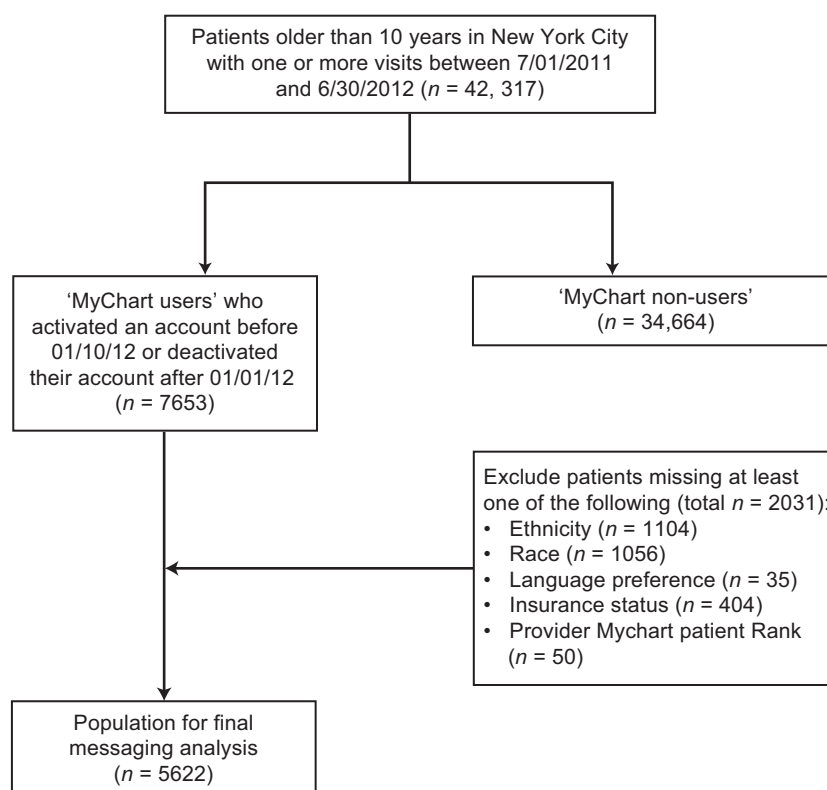


Figure 1: Flow of patients to the final messaging analysis

sent by these patients. Of this 7653 patient group, 2031 (26.54%) were missing values for one or more of the predictor variables and were thus excluded from analysis, leaving 5622 (73.46%) patients in the final analysis. The flow of patients through the study can be observed in Figure 1.

Due to over-dispersion in the count data for the number of messages sent and the preponderance of zero counts, a zero-inflated negative binomial (ZINB) model was fit to determine the patient characteristics that were associated with sending messages. ZINB models assume that observed zero counts could be attributed to random chance or to a structural reason, such as not having access to a computer, that arises from the nature of the data.^{23,24} The ZINB model contains two separate models: a logistic model investigating the odds of having excess zeroes beyond random chance and a negative binomial model to model the messaging counts of patients who send messages. The model produces an odds ratio (OR) for sending zero messages, as well as an incident rate ratio (IRR) for the messaging count.

Bivariate regression analyses were initially performed to determine which covariates were significantly associated ($p < 0.05$) with sending messages. To avoid collinearity, Spearman correlations were calculated between all possible pairs of covariates, and if covariates were correlated ($\rho > 0.4$), then the variable with the smallest effect size was dropped from modelling. Pearson χ^2 tests were used to compare messaging count values across levels of covariates, and categories were collapsed when differences between

levels were not statistically significant. All significant covariates were put into the final full models. Likelihood ratio tests and comparisons of Akaike information criteria and Bayesian information criteria values were used to compare the full model to nested models to determine the best fit model. With the given sample size, we can detect an effect size of 0.8% with a significance level of 1% and 99% power. All statistical analyses were performed with SAS 9.3.

RESULTS

Table 1 shows the results of bivariate analyses comparing the characteristics of MyChart users and non-users. It includes the percentage of missing values for each variable. MyChart users were more likely to be either in the Millennial generation or Generation X, female, of white race, have an English language preference and have more office visits than non-users. MyChart users lived in neighbourhoods that had higher median incomes, higher percentages of high school graduates and lower percentages of people below the poverty level. The largest difference between MyChart users and non-users was the MyChart patient ratio of their most-seen provider – users were much more likely to have had providers with higher MyChart patient ratios.

Table 2 shows the results of the multivariate ZINB regression models exploring the relationship between patient characteristics and sending messages amongst MyChart users. Compared with the Millennial generation, all of the

Table 1 Bivariate analysis of demographic differences between MyChart users and non-users. The groups differ on all variables listed at a level of $p < 0.0001$

Variables		MyChart user (n = 7653)	MyChart non-user (n = 34,664)
Generation			
	Youngest	674 (8.81%)	5961 (17.20%)
	Millennial	3326 (43.46%)	11,470 (33.09%)
	Generation X	1864 (24.36%)	6502 (18.76%)
	Young Boomers	1031 (13.47%)	5616 (16.20%)
	Older Boomers	515 (6.73%)	3162 (9.12%)
	Silent	169 (2.21%)	1254 (3.62%)
	GI	74 (0.97%)	699 (2.02%)
Gender			
	Male	2270 (29.66%)	13,893 (40.08%)
	Female	5383 (70.34%)	20,771 (59.92%)
White race			
	Yes	2285 (29.85%)	5393 (15.56%)
	No	4312 (56.34%)	24,293 (70.08%)
	Missing	1056 (13.80%)	4978 (14.36%)
Ethnicity			
	Non-Hispanic	3940 (51.48%)	16,497 (47.59%)
	Hispanic	2609 (34.09%)	13,653 (39.39%)
	Missing	1104 (14.43%)	4514 (13.02%)
English language preference			
	Yes	7279 (95.11%)	29,611 (85.42%)
	No	339 (4.43%)	4635 (13.37%)
	Missing	35 (0.05%)	418 (1.21%)
Insurance type			
	Private	3556 (46.47%)	8740 (25.21%)
	Public	2976 (38.89%)	17,520 (50.54%)
	Uninsured	717 (9.36%)	5426 (15.65%)
	Missing	404 (5.28%)	2978 (8.59%)
Number of diagnoses			
	0	4041 (52.80%)	19,742 (56.95%)
	1	2082 (27.21%)	8432 (24.32%)
	2 or more	1530 (19.99%)	6490 (18.72%)
Visits during the year			
	Lowest 3rd (1 visit)	1608 (21.01%)	10,170 (29.34%)
	Middle 3rd (2–4 visits)	3236 (42.28%)	14,130 (40.76%)
	Top 3rd (5–336 visits)	2809 (36.70%)	10,364 (29.90%)
Provider MyChart patient ratio			
	Lowest 3rd (0%–17.88%)	661 (8.64%)	13,597 (39.23%)
	Middle 3rd (18.72%–33.78%)	2856 (37.32%)	10,796 (31.14%)
	Top 3rd (34.22%–100%)	4086 (53.39%)	9787 (28.23%)
	Missing	50 (0.65%)	484 (1.40%)
ZIP code median income			
	Lowest 3rd (19.84–29.06)	1967 (25.70%)	11,787 (34.01%)
	Middle 3rd (30.41–47.77)	2448 (31.99%)	12,082 (34.86%)
	Top 3rd (48.40–191.90)	3238 (42.31%)	10,792 (31.14%)
	Missing	0 (0.0%)	3 (0.0%)
ZIP code per cent below poverty level			
	Lowest 3rd (0%–17.1%)	3103 (40.55%)	10,908 (31.47%)
	Middle 3rd (17.4%–30.90%)	2423 (31.66%)	11,717 (33.80%)
	Top 3rd (31.60%–42.90%)	2127 (27.79%)	12,036 (34.72%)
	Missing	0 (0.0%)	3 (0.0%)
ZIP code per cent high school graduate			
	Lowest 3rd (50.80%–62.90%)	2208 (28.85%)	12,782 (36.88%)
	Middle 3rd (63.50%–81.10%)	2261 (29.54%)	10,561 (30.47%)
	Top 3rd (81.20%–98.80%)	3184 (41.60%)	11,318 (32.65%)
	Missing	0 (0.0%)	3 (0.0%)

Table 2 Final multivariate model showing patient characteristics in relation to message sending behaviour

		Increased messaging rate (95% CI)	Odds of having excess zeroes (95% CI)
Variable		IRR (95% CI)	OR (95% CI)
Generation			
	Youngest	0.97 (0.82, 1.15)	2.00 (1.38, 2.91)**
	Millennials	Reference	Reference
	Generation X	1.14 (1.04, 1.25)**	1.38 (1.06, 1.79)*
	Baby Boomers	1.25 (1.13, 1.38)***	1.64 (1.24, 2.17)**
	Silent and GI Generations	1.50 (1.25, 1.81)***	1.25 (0.72, 2.19)
Number of office visits			
	Lowest 3rd (1–2 visits)	Reference	Reference
	Middle 3rd (3–4 visits)	1.02 (0.93, 1.13)	1.11 (0.8, 1.54)
	Top 3rd (5–161 visits)	1.14 (1.03, 1.26)**	2.22 (1.64, 3.01)***
Number of messages received			
	Lowest 3rd (0–2 messages)	Reference	Reference
	Middle 3rd (3–7 messages)	3.23 (2.74, 3.82)***	0.18 (0.13, 0.26)***
	Top 3rd (8–2589 messages)	11.50 (9.72, 13.62)***	0.08 (0.06, 0.12)***
Number of diagnoses			
	0	Reference	Reference
	1	1.18 (1.09, 1.28)**	1.38 (1.06, 1.77)*
	2 or more	1.20 (1.08, 1.32)**	1.92 (1.45, 2.54)***
White race			
	Yes	1.17 (1.09, 1.27)***	0.56 (0.42, 0.75)***
	No	Reference	Reference
English language preference			
	Yes	Reference	–
	No	0.74 (0.61, 0.89)**	–
Gender			
	Female	Reference	–
	Male	0.88 (0.82, 0.95)**	–
Per cent people in ZIP code who graduated high school			
	Lowest 3rd (50.80%–69.40%)	0.88 (0.82, 0.96)**	–
	Middle and top 3rd (69.80%–83.10%)	Reference	–
Provider sends messages			
	Yes	Reference	–
	No	0.85 (0.74, 0.99)*	–
Per cent people in ZIP code above poverty level			
	Lowest and Middle 3rd (0%–28.30%)	–	Reference
	Top 3rd (28.40%–42.90%)	–	1.30 (1.06, 1.60)*
Insurance Type			
	Private	–	Reference
	Public	–	2.02 (1.61, 2.54)***
	Uninsured	–	2.03 (1.43, 2.90)***
Per cent of provider's patients who use MyChart			
	Lowest 3rd (0%–30.43%)	–	Reference
	Middle 3rd (30.52%–38.62%)	–	0.60 (0.48, 0.75)***
	Top 3rd (38.77%–75.00%)	–	0.45 (0.34, 0.60)***

*Significant at level $p = 0.05$. **Significant at level $p = 0.01$.***Significant at level $p < 0.0001$.

older generations had higher messaging rates. In contrast, all generations aside from the G.I. and Silent generations had higher odds than the Millennials of having an excess of people who sent zero messages. Patients with the most office visits and also patients with more of the counted diagnoses were more likely to not use messaging, but those who did use messaging sent more messages. Patients of white race sent more messages and were also less likely to send zero messages. Patients who were male, who were non-English speaking, whose most-seen provider did not send messages and who lived in a neighbourhood with a lower high school graduation rate sent fewer messages. Patients who lived in a neighbourhood with more people below the poverty level and patients who had public insurance or were uninsured had increased odds of sending zero messages. Patients whose providers had higher MyChart patient ratios were less likely to send zero messages. The largest effect sizes were seen for the number of messages received, with patients who received more messages sending significantly more messages and being much less likely to send zero messages.

DISCUSSION

Principal findings

The largest factor associated with higher levels of messaging usage was the number of messages received by the patient. Patients who received more messages had a much higher messaging rate and lower odds of sending zero messages. The effects of age on messaging usage were not straightforward. As compared with Millennials, older generational age was seen as a moderate predictor of sending more messages, and the expected number of messages sent increased as the age grouping increased. However, compared to Millennials, the youngest generation, Generation X and Baby Boomers had increased odds of sending zero messages while the oldest generations did not. Our study found nuanced electronic messaging usage patterns for patients based on health status. Patients with more diagnoses and more office visits tended to send more messages, but they also had higher odds of sending zero messages. We also observed that factors that are generally associated with social disparities and the 'digital divide' persisted in this population after controlling for many covariates. Patients who were male, of non-white race, who had a non-English language preference, who used public insurance or were uninsured and who lived in ZIP codes with higher levels of poverty and lower levels of high school graduation tended to have decreased electronic messaging usage.

Implications of findings

These findings indicate that increased provider usage of an electronic messaging system may be associated with greater patient usage of such systems, though future research is needed to substantiate these results. We also found that controlling for the receipt of electronic messages and health status did not remove the association between socioeconomic

factors and messaging usage. This underscores the need for health care organisations to generate new strategies to encouraging usage in disadvantaged groups when implementing or advertising patient portals or similar patient-provider communication systems.

Comparison with literature

Previous studies show that provider adoption of a system is associated with patient adoption. A retrospective study of older patients with diabetes found that patients whose providers sent more electronic messages visited their patient portal more often.¹⁷ A literature review that investigated barriers to the use of interactive consumer HIT tools for patient who were older, underserved, or had chronic conditions found that active and timely interactions with clinicians increased patient satisfaction with HIT systems.⁵ These results seem to agree with the results found in this study where receiving more messages prompts patients to send more messages, though this study was not able to determine who initiated contact in an e-mail chain. Our findings of decreased electronic messaging usage among patients who are male, of non-white race, who had a non-English language preference, who used public insurance or were uninsured and who lived in ZIP codes with higher levels of poverty and lower levels of high school graduation, are consistent with multiple previous studies that found such factors to be associated with decreased Internet and electronic system usage.^{5-7,9} Previous studies show inconsistent results in terms of how age affects electronic system usage. Studies have found that older patients are less likely to use the Internet⁷ and phone texting,²⁰ and that middle aged patients are more likely to use electronic messaging¹⁶ and are more likely to activate electronic patient portal accounts.⁶ In contrast, this study found that older adults tended to send more messages, and that the Baby Boom generation was more likely to send zero messages. A previous review of consumer HIT systems⁹ did not see a consistent relationship between system usage and age. Overall, the research does not paint a clear picture of how age affects messaging. Our results concerning health status are congruent with a 2007 Pew Internet & American Life Project report²⁵ which found that patients with more chronic diseases were less likely to use the Internet but more likely to be high volume users when they do go online. Previous studies have also found that patients with higher levels of morbidity were more likely to be electronic messaging users¹⁶ and repeat patient portal users.⁶

A previous study by Ralston et al¹⁶ investigated patient messaging counts using a Poisson regression model and a similar array of covariates. In contrast to our study, Ralston found only age and measures of morbidity to be significant predictors of an increased tendency to send messages. Our study's usage of raw messaging counts, as opposed to the Ralston study's usage of threads, may be the reason why our study found a wider array of significant covariates. Threads can encompass a large number of messages, which would necessarily depress the magnitude of the outcome being

considered in Ralston's models. Differences could also be due to our use of the ZINB model, which explicitly identifies patient groups that have greater odds of not using the messaging system. Pronounced differences between the two studies may also be due to demographic differences in the study populations.

Limitations of the method

While we found large associations between sending and receiving messages, there are a number of possible explanations for this result. First, the cross-sectional nature of our data does not consider whether the patient or the provider sent the first message in a messaging chain, therefore we cannot determine whether the patients or the providers initiated contact. Second, we counted all messages exchanged with the patient, which would include communications such as automated reminders and billing inquiries. It is therefore possible that a bulk of a patient's messaging did not involve their provider. A third limitation is in the interpretation of the excess zero count modelled in the ZINB model. While it is probable that a lack of messaging could be due to certain structural factors that would preclude the sending of electronic messages, this study is unable to identify what those factors are. Fourth, this study also had a large amount of missing data, leading to an exclusion of 26.54% of MyChart-using patients from the final regression analyses. A majority of these exclusions were due to missing ethnicity and race data. It is possible that the excluded participants may have different characteristics from the sample that was studied. Fifth, this study collected diagnoses for a limited number of chronic conditions whereas a previous study used a comorbidity index that considered both ICD-9 codes and demographic information,¹⁶ which could account for the differences seen when considering the patient's health status. Finally, this study was performed in an urban environment and may not be generalisable to other health care settings.

Call for future research

Future studies should consider the timing of patient and provider messaging and filter out non-medical electronic messages to define a clearer link between provider and patient adoption. A number of studies have shown a link between socioeconomic status and electronic system usage. Future studies should focus on why these differences exist and how to remediate them, especially in the face of current efforts to target these electronic systems to groups with lower socioeconomic status. These results are of special interest in this case since the FQHC works consistently with underprivileged groups and makes strides to ensure that all of their patients have an opportunity to interact with their providers electronically. For example, before this study this

FQHC implemented a Spanish-language version of MyChart containing the same features as the English-language version. This Spanish-language version underwent significant review for cultural appropriateness before implementation, yet it this study still found that people with a Spanish-language preference were less likely to use MyChart than people who preferred English. A previous study investigating the characteristics of patients without computer access⁸ found that people who lacked of a high school diploma, people of retirement age, people of any race other than white and people with public insurance were at greater risk of not having access to a computer. While those same factors are associated with sending zero messages in this study, we cannot determine whether the association seen was caused by a lack of computer access. Previous studies found that a wide range of factors, from lacking physical access to computers to social factors, are associated with patients not using electronic systems.^{5,8}

CONCLUSIONS

Differences in message sending due to message receipt, gender, age, race, language preference, clinic visit volumes, socioeconomic factors and comorbidities persist even after adjusting for multiple covariates. This analysis of an existing EHR data set adds to the body of research supporting the existence of links between provider engagement and socioeconomic status and electronic system usage, but it does not explain why these differences exist. Future studies need to not only focus on specific socioeconomic factors that relate to usage, but use methodologies that can determine the causes of these differences.

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REFERENCES

1. Jha AK, Burke MF, DesRoches C, Joshi MS, Kralovec PD, Campbell EG et al. Progress toward meaningful use: hospitals' adoption of electronic health records. *The American Journal of Managed Care* 2011;17(12 Spec No.):SP117–24.
2. Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E et al. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Annals of Internal Medicine* 2006;144(10):742–52. <http://dx.doi.org/10.7326/0003-4819-144-10-200605160-00125>. PMID:16702590.
3. Amarasingham R, Plantinga L, Diener-West M, Gaskin DJ and Powe NR. Clinical information technologies and inpatient outcomes: a multiple hospital study. *Archives of Internal Medicine* 2009;169(2):108–14. <http://dx.doi.org/10.1001/archinternmed.2008.520>. PMID:19171805.
4. Brodie M, Flournoy RE, Altman DE, Blendon RJ, Benson JM and Rosenbaum MD. Health information, the Internet, and the digital divide. *Health Affairs* 2000;19(6):255–65. <http://dx.doi.org/10.1377/hlthaff.19.6.255>. PMID:11192412.
5. Jimison H, Gorman P, Woods S, Nygren P, Walker M, Norris S et al. Barriers and drivers of health information technology use for the elderly, chronically ill, and underserved. *Evidence Report Technology Assessment (Full Report)* No.175,2008,1–1422.
6. Ancker JS, Barron Y, Rockoff ML, Hauser D, Pichardo M, Szerencsy A et al. Use of an electronic patient portal among disadvantaged populations. *Journal of General Internal Medicine* 2011;26(10):1117–23. <http://dx.doi.org/10.1007/s11606-011-1749-y>. PMID:21647748; PMCID:PMC3181304
7. Kruse RL, Koopman RJ, Wakefield BJ, Wakefield DS, Keplinger LE, Canfield SM et al. Internet use by primary care patients: where is the digital divide? *Family Medicine* 2012;44(5):342–7.
8. Green BB, Anderson ML, Ralston JD, Catz S, Fishman PA and Cook AJ. Patient ability and willingness to participate in a web-based intervention to improve hypertension control. *Journal of Medical Internet Research* 2011;13(1):e1. <http://dx.doi.org/10.2196/jmir.1625>. PMID:21371993; PMCID:PMC3217242.
9. Or CK and Karsh BT. A systematic review of patient acceptance of consumer health information technology. *Journal of the American Medical Informatics Association* 2009;16(4):550–60. <http://dx.doi.org/10.1197/jamia.M2888>. PMID:19390112; PMCID:PMC2705259.
10. Horvath M, Levy J, L'Engle P, Carlson B, Ahmad A and Ferranti J. Impact of health portal enrollment with email reminders on adherence to clinic appointments: a pilot study. *Journal of Medical Internet Research* 2011;13(2):e41. <http://dx.doi.org/10.2196/jmir.1702>. PMID:21616784; PMCID:PMC3221371.
11. Muller D, Logan J, Dorr D and Mosen D. The effectiveness of a secure email reminder system for colorectal cancer screening. *AMIA Annual Symposium Proceedings* 2009;2009:457–61.
12. Zhou YY, Kanter MH, Wang JJ and Garrido T. Improved quality at Kaiser Permanente through e-mail between physicians and patients. *Health Affairs (Millwood)* 2010;29(7):1370–5. <http://dx.doi.org/10.1377/hlthaff.2010.0048>. PMID:20606190.
13. Lin H, Chen W, Luo L, Congdon N, Zhang X, Zhong X et al. Effectiveness of a short message reminder in increasing compliance with pediatric cataract treatment: a randomized trial. *Ophthalmology* 2012;119(12):2463–70. <http://dx.doi.org/10.1016/j.ophtha.2012.06.046>. PMID:22921386.
14. Centers for Medicare and Medicaid Services. Stage 2 Eligible Professional Meaningful Use Core Measures, Measure 17. Services CfMaM (Ed), 2012.
15. 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. *Journal of General Internal Medicine* 2013;28(7):914–20. <http://dx.doi.org/10.1007/s11606-012-2329-5>. PMID:23423453; PMCID:PMC3682038.
16. Ralston JD, Rutter CM, Carrell D, Hecht J, Rubanowicz D and Simon GE. Patient use of secure electronic messaging within a shared medical record: a cross-sectional study. *Journal of General Internal Medicine* 2009;24(3):349–55. <http://dx.doi.org/10.1007/s11606-008-0899-z>. PMID:19137379; PMCID:PMC2642567.
17. Weppner WG, Ralston JD, Koepsell TD, Grothaus LC, Reid RJ, Jordan L et al. Use of a shared medical record with secure messaging by older patients with diabetes. *Diabetes Care* 2010;33(11):2314–9. <http://dx.doi.org/10.2337/dc10-1124>. PMID:20739686; PMCID:PMC2963486.
18. New York State Department of Health. ZIP Code Definitions of New York City Neighborhoods 2006 [updated March 2006; cited 2013]; Available from: <http://www.health.ny.gov/statistics/cancer/registry/appendix/neighborhoods.htm>.
19. Zickuhr K. Generations 2010. 2010.
20. Gauthier C, Lindwall E, Davis W and Quinet R. Spanning generations-appointment reminder preferences among patients with rheumatic diseases. *Journal of Clinical Rheumatology* 2012;18(6):294–7. <http://dx.doi.org/10.1097/RHU.0b013e3182676b6b>. PMID:22955478.
21. United States Census Bureau. American FactFinder. [cited 2013 June]; Available from: <http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>.
22. UDS Mapper. ZIP Code to ZCTA Crosswalk. [March 2013]; Available from: <http://udsmapper.org/zip2zctacrosswalk.cfm>.
23. Hu MC, Pavlicova M and Nunes EV. Zero-inflated and hurdle models of count data with extra zeros: examples from an HIV-risk reduction intervention trial. *The American Journal of Drug and Alcohol Abuse* 2011;37(5):367–75. <http://dx.doi.org/10.3109/00952990.2011.597280>. PMID:21854279; PMCID:PMC3238139.
24. Xie H, Tao J, McHugo GJ and Drake RE. Comparing statistical methods for analyzing skewed longitudinal count data with many zeros: an example of smoking cessation. *Journal of Substance Abuse Treatment* 2013.
25. Fox S. E-patients with a disability or chronic disease. Pew Internet and American Life Project, 2007.