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Original Article

Patient Portal Utilization Improves Outcomes in Patients with Multiple Myeloma

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Abstract

Background and objectives: A growing body of literature has demonstrated improved quality of life in cancer patients who utilize web-based patient portals; however, no studies have investigated their impact on objective clinical measures. The study aimed to evaluate the impact of patient portal utilization on clinical outcomes in cancer care. Patient portal platforms provide patients with direct access to their providers through messaging, medication requests, and other tools. There is a knowledge gap in the literature regarding whether electronic patient portals enhance outcomes in cancer care.

Methods: This study is a retrospective analysis of 791 patients with multiple myeloma within the Scripps Health system. The effect of MyScripps electronic patient portal use on unplanned hospital visits and mortality was assessed. Outcomes were also evaluated in relation to the age-adjusted Charlson comorbidity index and chemotherapy use.

Results: Results showed that older, male, Hispanic, and Spanish-speaking patients had lower portal utilization. Those with inactive portal status had higher rates of unplanned hospital visits and mortality. Inactive portal status was an independent predictor of unplanned hospital visits in two multivariable logistic regression analyses. A logistic regression model investigating the interaction between patient portal use and age-adjusted Charlson comorbidity index revealed that active portal status remained a predictor of unplanned hospital visits.

Conclusions: This study highlights the potential to improve clinical outcomes among patients with multiple myeloma, particularly in vulnerable communities, by increasing access to electronic patient portals.

Introduction

The adoption of electronic health record systems and web-based patient portals by hospitals has created new tools for patient-centered care with significant potential to improve clinical outcomes. Several studies have investigated the impact of patient portal use on patient-centered endpoints in various chronic diseases. In general, patient portal use was found to have a positive effect on metrics such as medication adherence and objective clinical outcomes.[1–5] A recent systematic review by Han *et al*.[1] evaluated patient portal interventions and their effects on clinical and psychobehavioral outcomes. They analyzed 24 studies, including randomized controlled trials, quasi-experimental studies, mixed methods studies using surveys and focus groups, and retrospective cohort studies. They found that patient portal interventions had a consistently positive effect on behavioral outcomes such as medication adherence and engagement in preventive health care screenings, such as colorectal cancer screening. However, the review also revealed mixed results regarding the impact of patient portal use on clinical outcomes and insufficient evidence of an effect on various clinical measures such as blood pressure or glucose control. These findings contrast with those from a systematic review performed by Alturkistani *et al*.,[2] which reported overall improved glycemic control, reduced HgbA1c, and reduced hospitalizations in diabetic patients who actively use patient portals. Similarly, a review by Jeminiwa *et al*.[3] demonstrated improved inhaled corticosteroid adherence in asthmatic patients who use patient portals versus those who do not. Comparatively, little research has examined the effect of patient

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portal use on outcomes in cancer patients.[6]

Furthermore, Han *et al*.[1] noted that the studies in their review included primarily white, middle-aged, English-speaking populations and called for further investigation into the effects of patient portal use on outcomes among patients from more diverse backgrounds. The lack of diversity in these studies is consistent with previous findings of web-based portal underutilization by patients from minority groups and highlights a potential strategy for improving health outcomes in vulnerable populations.[7,8] The goal of this study was to evaluate the impact of patient portal utilization on clinical outcomes in cancer care. Patient portal platforms provide patients with direct access to their providers through messaging, medication requests, and other tools. There is currently a knowledge gap in the literature regarding whether electronic patient portals enhance outcomes in cancer care. We hope to gain a better understanding of how the patient portal can be used to enhance care and improve patient outcomes. In this study, we evaluated the effect of patient portal use by patients with multiple myeloma on clinical outcomes and identified patient characteristics associated with active portal use. By understanding the web-based patient portal utilization characteristics of cancer patients and the effects of portal use on clinical outcomes, we can optimize web-based portal access and experience for patients to improve cancer outcomes, particularly for marginalized patients who often suffer from poor health outcomes.

Materials and methods

Sample and design

In this retrospective study, we analyzed data from 791 patients diagnosed with multiple myeloma, from the launch of the Scripps Health MyChart patient portal on April 1, 2017, through September 1, 2021. We compared the clinical outcomes of patients who utilized the MyChart portal to those who did not. Patient portal use was defined as patients who were actively enrolled in the patient portal platform. All patients with a diagnosis of multiple myeloma who were 18 years or older were included in the study. Data were collected from January 1, 2019, to January 1, 2021. Primary clinical outcomes were electronic health record (EHR)-documented unplanned hospital visits and all-cause mortality during the study period. Unplanned hospital visits were used as a surrogate for clinical outcomes, as other measures of disease control in myeloma (e.g., serum monoclonal protein, clonal plasma cells in bone marrow) cannot be easily extracted from the electronic medical record and would not be feasible for a study of this size. We used zip codes for regions defined by San Diego Health and Human Services to capture differences in socioeconomic status based on geographical location.

Statistical analyses

Comparisons between active portal users and inactive portal users were conducted using Chi-square tests or Fisher's exact tests for categorical variables and t-tests or Mann-Whitney U tests for continuous variables. We analyzed differences in various demographic variables between active and inactive portal users. The differences between demographic variables and the primary outcomes of unplanned hospital admissions and death were analyzed using Chi-square tests and Mann-Whitney U tests. An exploratory analysis was performed using simple and multiple logistic regression to identify predictors of unplanned hospital visits. Univariable logistic regression assessed associations between individual patient and clinical variables and the outcomes, informing the variables to be used in multivariable logistic regression. Only variables with *P*-values less than 0.05 were considered in the multivariable models, along with any variables with a significant intercept. Additional exploratory analyses were conducted using Chi-square tests and logistic regressions to further investigate disparity variables. Two-tailed *P*-values less than 0.05 were considered statistically significant.

Many patients with multiple myeloma suffer from one or more comorbidities at the time of their cancer diagnosis; therefore, we included the age-adjusted Charlson comorbidity index (ACI) score as a variable in our analyses. The Charlson comorbidity index (CCI) is a validated tool that enables clinicians to predict the mortality of patients with multiple chronic conditions.[9] The CCI consists of 17 comorbidities, with two subcategories for diabetes and liver disease.[10] Comorbidities are weighted from one to six based on mortality risk and disease severity, and then summed to form the total CCI score.[10] The ACI score incorporates age as an additional comorbidity by adding one point to the CCI score for each decade of age over 40 years.[10] We evaluated the number of comorbidities and calculated the comorbidity burden using the ACI, categorizing it into scores of less than six and six or greater, as described by others.[11,12] We assessed associations between various patient and clinical variables with low burden (ACI < 6) or high burden (ACI ≥ 6). If a variable was significantly associated with ACI burden ($P < 0.05$), it was analyzed in exploratory univariable and multivariable logistic regressions. Variables significant at the univariable level were added to the multivariable model, which included a significant intercept. We also estimated the predictive value of patient and clinical variables for a high ACI score as the outcome, as well as the predictive value of the ACI score for unplanned hospital visits as the outcome, in both univariable and multivariable analyses.

All analyses were conducted using R v. 4.0.3 in the R Studio environment. CCI scores were calculated using the comorbidity package in R.

Results

Sociodemographic characteristics of patients with active portal usage

Associations between portal use and sociodemographic variables are summarized in Table 1. Patients active on the portal were significantly younger (mean age of 71.8 ± 10.1 years) compared to inactive patients (mean age of 74.3 ± 11.7 years; $P < 0.001$). Males (53.02%) were also more likely to be inactive on the portal compared to females ($P = 0.0434$). Portal activity was higher among non-Hispanic patients (86.58%) than Hispanic patients (10.74%) ($P < 0.001$). The San Diego regions with the highest rates of portal utilization were the North Coastal region at 30.2%, followed by the North Inland region at 17.9%. These are more affluent regions of San Diego with the lowest levels of poverty, as shown in Figure 1. The regions with the lowest portal utilization were the more impoverished Central and Southern regions, with rates of 4.3% and 5.8%, respectively (Fig. 1). More active users lived in the North Coastal, North Inland, North Central, and Eastern regions, while more inactive users were present in the Southern and Central regions ($P < 0.001$). English-speaking patients utilized the portal at higher rates (88.81%) than Spanish-speaking patients (3.36%) ($P < 0.001$). Never smokers were more likely to be active portal users ($P = 0.0104$). Patients with private insurance utilized the patient portal at a higher rate (33.11%), whereas patients with Medicare

Table 1. Demographic characteristics by patient portal activity status

Variable	Active (N = 447)	% or SD	Inactive (N = 344)	% or SD	*P*
Age (years), mean	71.78	10.09	74.33	11.72	0.00060
Sex					
Male	237	53.02%	208	60.47%	0.03639
Female	210	46.98%	136	39.53%	
Race					
White	360	80.54%	257	74.71%	0.12670
Asian	24	5.37%	22	6.40%	
Black	21	4.40%	29	8.43%	
Other/unknown	42	9.39%	36	10.47%	
Ethnicity					
Not Hispanic/Latino	387	86.58%	246	71.51%	<0.0001
Hispanic/Latino	48	10.74%	81	23.55%	
Other/unknown	12	2.68%	17	4.94%	
Region					
Central	26	5.82%	40	11.63%	<0.0001
East	30	6.71%	20	5.81%	
North Central	75	16.78%	55	15.99%	
North Coastal	135	30.20%	65	18.90%	
North Inland	80	17.90%	44	12.79%	
South	19	4.25%	52	15.12%	
Other	82	18.34%	68	19.77%	
Smoking status					
Never	269	60.18%	178	51.74%	0.01041
Former	149	33.33%	126	36.63%	
Current	17	3.80%	16	4.65%	
Unknown	12	2.68%	24	6.98%	
Language					
English	397	88.81%	279	81.10%	<0.0001
Spanish	15	3.36%	48	13.95%	
Other	7	1.57%	6	1.74%	
Unknown	28	6.26%	11	3.20%	
Insurance type					
Private	148	33.11%	72	20.93%	0.00020
Medicare	299	66.89%	272	79.07%	
Currently insured					
Yes	438	97.99%	329	95.64%	0.05641
No	9	2.01%	15	4.36%	

SD, standard deviation.

had a higher rate of inactivity (66.89%) ($P < 0.001$).

Clinical characteristics and outcomes for patients with active vs. inactive portal status

There were significant associations between portal use, ACI score, and the use of cancer-directed therapy, as well as the primary outcomes of unplanned hospital visits and death, as summarized in Table 2. Patients with a lower ACI score were more likely to be active portal users, whereas patients with a high ACI score were more likely to be inactive on the patient portal ($P < 0.001$,). The percentage of pa-

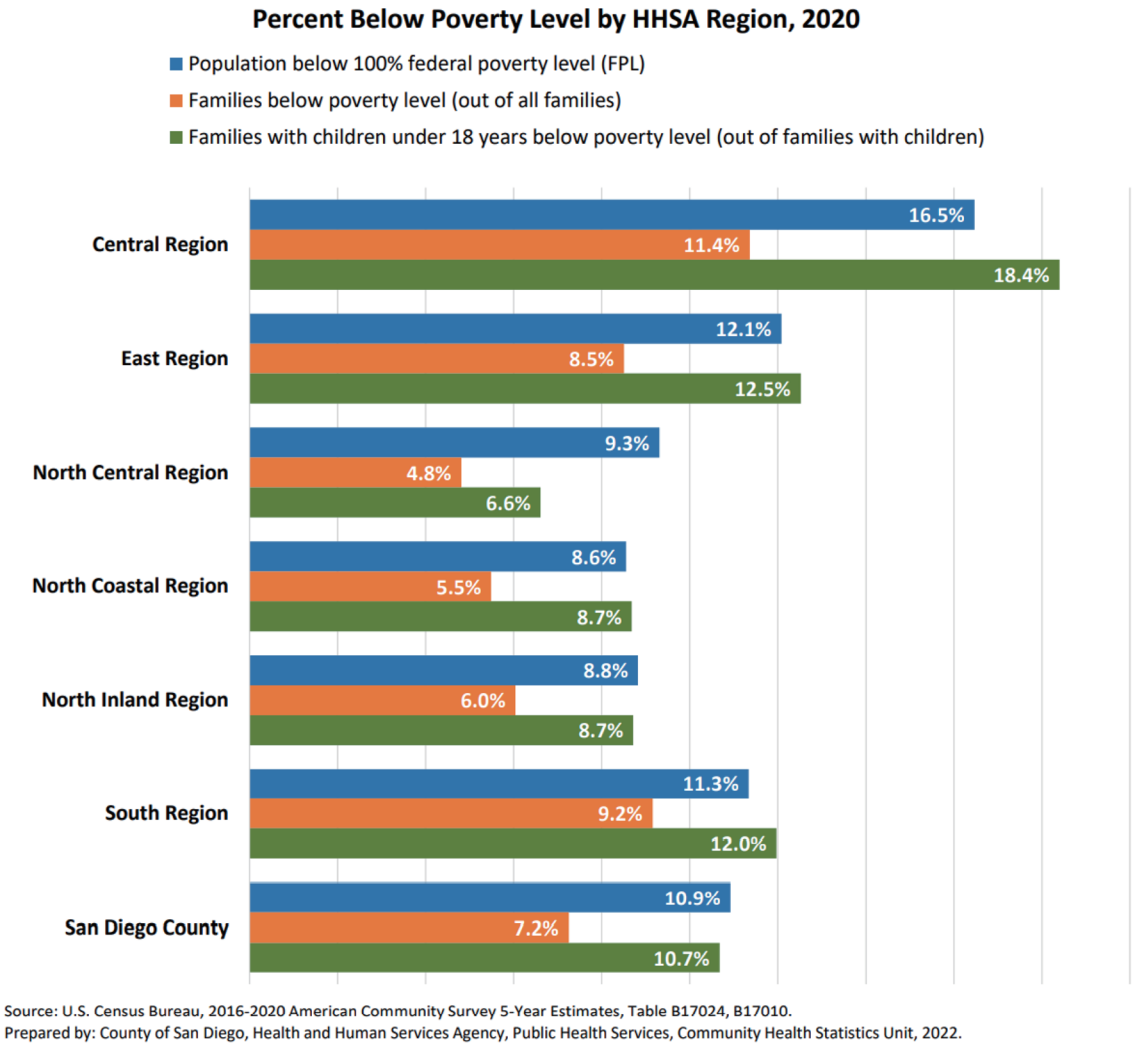

Fig. 1. In 2020, 10.9% of people, 7.2% of families, and 10.7% of families with children under the age of 18 in San Diego County were in poverty. HHSA, Health and Human Services Agency.

Table 2. Association of patient portal activity status with clinical characteristics and outcomes

Outcome variable	Active (N = 447)	%	Inactive (N = 344)	%	*P*
Age-adjusted CCI score					
0–5	160	35.79%	72	20.93%	<0.0001
6+	287	64.21%	272	79.07%	
Unplanned hospital visits					
Yes	272	60.85%	255	74.13%	0.0001
No	175	39.15%	89	25.87%	
Status					
Alive	446	99.78%	210	61.05%	<0.0001
Dead	1	0.22%	134	38.95%	
Chemotherapy					
Yes	256	53.67%	155	45.06%	0.0007
No	191	40.04%	189	54.94%	

CCI, Charlson comorbidity index.

tients on cancer-directed therapy was higher among active portal users (53.67%) compared to inactive portal users (45.06%) ($P < 0.001$). A greater percentage of patients with unplanned hospital visits were inactive portal users, whereas a greater percentage of patients with no unplanned hospital visits were active portal users ($P < 0.001$).

Patient portal activity status and other predictors of unplanned hospital visits

Table 3 presents the findings from exploratory analyses of predictors for the primary outcome of unplanned hospital visits. Active portal use, older age, Hispanic ethnicity, current smoker status, living in the South region, Medicare, use of cancer-directed therapy, death, and high ACI burden were all individual predictors of having an unplanned hospital visit in univariable modeling. Notably, patients who were active on the patient portal had lower odds of having an unplanned hospital visit compared to those who were inactive (56.5% vs. 43.5%; odds ratio = 0.543; 95% confidence interval [0.398–0.736]; $P < 0.001$). In multivariable modeling, the use of cancer-directed therapy and an ACI score of six or greater remained predictors of unplanned hospital visits, while patient portal use was no longer significant (Table 3).

We suspected that patients with more comorbidities would have more hospital visits, independent of their activity on the patient portal. An additional logistic regression analysis was conducted to control for the ACI score. Both active portal use and ACI score were found to be predictive of unplanned hospital visits. ACI was predictive in both univariable and multivariable models. Active portal users were less likely to have unplanned hospital visits, and this remained true when accounting for ACI.

Discussion

We showed that active patient portal utilization was associated with significantly lower rates of unplanned hospital visits and death in a diverse cohort of patients with multiple myeloma in San Diego County. Patient portal use remained an independent predictor of unplanned hospital visits in multivariable logistic regression analysis that included ACI. However, when additional significant variables were added to the model, cancer-directed therapy and ACI remained predictors of unplanned hospital visits, while patient portal use was no longer significant. Death was more likely in patients who had never enrolled in the patient portal. This finding is intriguing but warrants further investigation to better understand the association. We also observed that older patients were less likely to use the portal, which may correlate with a higher risk of death. Further prospective studies could elucidate outcomes in patients not utilizing the patient portal. While these findings do not prove a correlation between death and portal use, they support further research in this area. Studies measuring the impact of patient portal utilization in other diseases, such as diabetes, hypertension, and preventative care, have shown mixed results.[1–5] The lower rates of unplanned hospital visits and deaths seen in our patient population may indicate a potential benefit of leveraging this technology to improve care for patients with multiple myeloma. Previous studies have assessed patient satisfaction, overall views toward the technology, improved communication, and other patient perceptions.[6] However, no prior studies have evaluated the impact of patient portal utilization on outcomes in multiple myeloma or other cancers. There are several limitations to the retrospective design of this study, and while the results are promising, further investigation via prospective studies is warranted to explore the potential advantages of telehealth in reducing disparities in cancer care for vulnerable populations.

Patient portal utilization in our study cohort also highlights important healthcare disparities. Baseline differences in sociodemographic variables were observed; the groups with the lowest utilization of the online patient portal were older patients, Hispanic patients, Spanish speakers, Medicare recipients, smokers, and patients living in low-income areas, such as the U.S.-Mexico border community in Southern San Diego. Notably, elderly patients, Spanish-speaking patients, and those from lower-income areas had poorer clinical outcomes.

We also found that being inactive on the patient portal was an independent predictor of unplanned hospital visits. In multivariable analysis, portal activity status was predictive of outcomes independent of comorbidity burden.

The treatment of multiple myeloma and other malignancies can be complex, often involving multi-agent cancer-directed therapy with intravenous, subcutaneous, and oral medications. Communication between the patient and their hematology care team is crucial for ensuring compliance with treatment and follow-up. Our findings suggest that access to and interaction with patient portals may improve outcomes for patients with multiple myeloma, particularly in vulnerable populations.

Our study has several limitations. The grouping of patients into active and inactive users based on their MyChart patient chart status provided a limited understanding of portal use. We did not investigate specific within-group differences in portal use, such as the number of patient-to-provider e-messages, which may have offered insight into how portal use activity affects hospital visits. This approach also did not allow us to stratify the cohort by level of activity on the patient portal to investigate differences in hospital visits between patients who were regularly versus infrequently active on the portal compared to inactive users. The clinical outcome of unplanned hospital visits, while important, is limited in specificity. Understanding the reasons for each patient's hospital visit would require a more thorough investigation beyond this study's scope. Finally, although this retrospective study sheds light on the potential for patient portals to help address healthcare disparities in patients with multiple myeloma, further investigation through randomized controlled trials is needed to address potential confounding factors and provide a clearer understanding of how patient portal utilization affects clinical outcomes, given the inherent limitations of retrospective chart reviews.

Conclusions

Digital healthcare resources, such as online patient portals, are promising technologies that may reduce barriers to access and improve outcomes in vulnerable populations. While research into the impact of electronic health resources is growing, prior studies have not evaluated the effect of patient portal activity on health outcomes in cancer patients. This study provides evidence that culturally tailored programs to increase access to electronic resources in underserved populations are likely to help close the gap in patient outcomes in these communities.

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Table 3. Exploratory logistic modeling of predictors of unplanned hospital visits

Variable	n (%)	Univariable			Multivariable		
		OR	95% CI	*P*	OR	95% CI	*P*
Active status							
No	344 (43.5)	REF	REF	REF			
Yes	447 (56.5)	0.5425	0.398–0.736	<0.0001			
Age (years), mean ± SD	72.89 ± 10.89	1.035	1.021–1.050	<0.0001			
Sex							
Female	(346, 43.7%)	REF	REF	REF			
Male	(445, 56.3%)	0.881	0.652–1.187	0.4050			
Race							
Asian	(46, 5.8%)	REF	REF	REF			
Black	(50, 6.3%)	0.667	0.294–1.542	0.3571			
Other/unknown	(78, 9.9%)	0.561	0.261–1.18	0.1323			
White	(617, 78%)	1.22	0.634–2.257	0.5415			
Ethnicity							
Not Hispanic	(633, 80%)	REF	REF	REF			
Hispanic	(129, 16.3%)	2.455	1.546–4.051	0.0002			
Other/unknown	(29, 3.7%)	0.203	0.083–0.449	0.0002			
Smoking status							
Current	(33, 4.2%)	REF	REF	REF			
Former	(275, 34.8%)	0.634	0.245–1.445	0.3061			
Never	(447, 56.5%)	0.523	0.205–1.170	0.1378			
Unknown	(36, 4.6%)	0.152	0.049–0.429	0.0006			
Region							
Central	(66, 8.3%)	REF	REF	REF			
East	(50, 6.3%)	0.667	0.300–1.474	0.3155			
North Central	(130, 16.4%)	0.759	0.388–1.443	0.4075			
North Coastal	(200, 25.3%)	0.797	0.422–1.459	0.4713			
North Inland	(124, 15.7%)	0.732	0.374–1.398	0.3524			
Other	(150, 19%)	0.417	0.218–0.772	0.0065			
South	(71, 9%)	2.953	1.218–7.730	0.0202			
Insurance type							
Medicare	(571, 72.2%)	REF	REF	REF			
Private	(220, 27.8%)	0.510	0.370–0.704	<0.0001			
Chemotherapy							
No	(380, 48%)	REF	REF	REF	REF	REF	REF
Yes	(411, 52%)	2.867	2.113–3.911	<0.0001	2.701	1.944–3.774	<0.001
Language							
English	(675, 85.3%)	REF	REF	REF			
Other	(13, 1.6%)	1.788	0.541–8.031	0.3809			
Spanish	(63, 8%)	2.843	1.482–6.025	0.0032			
Unknown	(39, 4.9%)	0.858	0.446–1.702	0.6518			
Death							
No	(656, 82.9%)	REF	REF	REF	REF	REF	REF
Yes	(135, 17.1%)	7.090	3.829–14.677	<0.0001	4.666	2.520–9.492	<0.001
ACI score							
0–5	(232, 29.3%)	REF	REF	REF	REF	REF	REF
6+	(559, 70.7%)	4.639	3.353–6.449	<0.001	3.905	2.776–5.524	<0.001

ACI, age-adjusted Charlson comorbidity index; CI, confidence interval, OR, odds ratio; REF, reference; SD, standard deviation.

Conflict of interest

The authors have no relevant conflicts to disclose.

Author contributions

Conceptualization, methodology (EQ, AE), original draft preparation (EQ, AE, LP, SB, MX), draft review and editing (EQ, AG), formal analysis, data curation (LP, SB), and supervision (MX). All authors approved the final version of the manuscript for submission.

Ethical statement

This study was carried out in accordance with the recommendations of the Committee on Publication Ethics, the Declaration of Helsinki, and the recommendations for the conduct, reporting, editing, and publication of scholarly work from the International Committee of Medical Journal Editors. The study was approved by the Scripps Health IRB, and individual consent for this retrospective analysis was waived.

Data sharing statement

The data supporting the findings of this study will be made available by the corresponding author upon reasonable request after the publication of this manuscript.

References

[1] Han HR, Gleason KT, Sun CA, Miller HN, Kang SJ, Chow S, *et al*. Using Patient Portals to Improve Patient Outcomes: Systematic Review. JMIR Hum Factors 2019;6(4):e15038. doi:10.2196/15038, PMID: 31855187.

[2] Alturkistani A, Qavi A, Anyanwu PE, Greenfield G, Greaves F, Costelloe C. Patient Portal Functionalities and Patient Outcomes Among Patients With Diabetes: Systematic Review. J Med Internet Res 2020;22(9):e18976. doi:10.2196/18976, PMID:32960182.

[3] Jeminiwa R, Hohmann L, Qian J, Garza K, Hansen R, Fox BI. Impact of eHealth on medication adherence among patients with asthma: A systematic review and meta-analysis. Respir Med 2019;149:59–68. doi:10.1016/j.rmed.2019.02.011, PMID:30803887.

[4] Hazara AM, Durrans K, Bhandari S. The role of patient portals in enhancing self-care in patients with renal conditions. Clin Kidney J 2020;13(1):1–7. doi:10.1093/ckj/sfz154, PMID:32082547.

[5] Kern LM, Barrón Y, Dhopeshwarkar RV, Edwards A, Kaushal R, MPH & with the HITEC Investigators. Electronic health records and ambulatory quality of care. J Gen Intern Med 2013;28(4):496–503. doi:10.1007/s11606-012-2237-8, PMID:23054927.

[6] Coughlin SS, Caplan L, Young L. A Review of Web Portal Use by Oncology Patients. J Cancer Treatment Diagn 2018;2(6):1–6. doi:10.29245/2578-2967/2018/6.1154, PMID:30680374.

[7] Goel MS, Brown TL, Williams A, Hasnain-Wynia R, Thompson JA, Baker DW. Disparities in enrollment and use of an electronic patient portal. J Gen Intern Med 2011;26(10):1112–1116. doi:10.1007/s11606-011-1728-3, PMID:21538166.

[8] Sinha S, Garriga M, Naik N, McSteen BW, Odisho AY, Lin A, *et al*. Disparities in Electronic Health Record Patient Portal Enrollment Among Oncology Patients. JAMA Oncol 2021;7(6):935–937. doi:10.1001/jamaoncol.2021.0540, PMID:33830178.

[9] Charlson ME, Carrozzino D, Guidi J, Patierno C. Charlson Comorbidity Index: A Critical Review of Clinimetric Properties. Psychother Psychosom 2022;91(1):8–35. doi:10.1159/000521288, PMID:34991091.

[10] Roffman CE, Buchanan J, Allison GT. Charlson Comorbidities Index. J Physiother 2016;62(3):171. doi:10.1016/j.jphys.2016.05.008, PMID: 27298055.

[11] Dessai SB, Fasal R, Dipin J, Adarsh D, Balasubramanian S. Age-adjusted charlson comorbidity index and 30-day morbidity in pelvic surgeries. South Asian J Cancer 2018;7(4):240–243. doi:10.4103/sajc.sajc_241_17, PMID:30430092.

[12] Wu CC, Hsu TW, Chang CM, Yu CH, Lee CC. Age-adjusted Charlson comorbidity index scores as predictor of survival in colorectal cancer patients who underwent surgical resection and chemoradiation. Medicine (Baltimore) 2015;94(2):e431. doi:10.1097/MD.0000000000000431, PMID:25590852.