Scientific Research Publishing

International Journal of Clinical Medicine, 2024, 15, 465-477
https://www.scirp.org/journal/ijcm
ISSN Online: 2158-2882
ISSN Print: 2158-284X

Investigating the Correlation between Patient Education on Web-Based Portal Functionality and the Reduction in 30-Day Hospital Readmission Rates

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How to cite this paper: Mathur, A. (2024) Investigating the Correlation between Patient Education on Web-Based Portal Functionality and the Reduction in 30-Day Hospital Readmission Rates. *International Journal of Clinical Medicine*, **15**, 465-477.
https://doi.org/10.4236/ijcm.2024.1510030

Received: September 12, 2024
Accepted: October 27, 2024
Published: October 30, 2024

Abstract

Background: The growing use of web-based patient portals offers patients valuable tools for accessing health information, communicating with healthcare providers, and engaging in self-management. However, the influence of educating patients on these portals' functionality on clinical outcomes, such as all-cause readmission rates, remains underexplored. **Objective:** This research proposal tested the hypothesis that educating a subset of patients with Chronic Obstructive Pulmonary Disease (COPD) and Congestive Heart Failure (CHF), on how to effectively access and utilize the functionality of web-based patient portals can reduce all-cause readmission rates. **Methods:** We performed a prospective, quasi-experimental study at Bon Secours St. Mary's Hospital in Richmond, Virginia, USA; dividing participants into an intervention group, receiving education about accessing and navigating "My Chart", the Bon Secours Web based portal, and a control group, receiving standard care. We then compared 30-day readmission rates, patient engagement, and self-management behaviors between the groups. Data was analyzed using statistical tests to assess the intervention's impact. **Results:** We projected that educated patients will exhibit lower readmission rates, improved engagement, and better self-management. The results of the study showed that there was a significant decrease in 30-day readmissions in the intervention group in comparison with the control group (22.7% and 40.9%, respectively). This reduction of 18. 2% of readmissions evaluated here for a trial of meaningful clinical effect is statistically insignificant ($p = 0.184$). The practical significance of the intervention is considered small-to-moderate (Cramer $V = 0.20$) suggesting that the observed difference has a potential clinical importance even though the difference was not statistically significant. **Conclusion:** These results imply that the

proposed educational intervention might have a positive impact on readmissions; nonetheless, the patient's characteristics that make him or her capable of readmission cannot be changed and are assessed by the RoR (Risk of Readmission) score. The potential impact of the intervention may be offset, in part, by these baseline risk factors. The study's power may be limited by sample size, potentially affecting the detection of significant differences. Future studies with larger, multi-center samples and longer follow-up periods are recommended to confirm these findings.

Keywords

All Cause Hospital Readmission, Chronic Obstructive Pulmonary Disease, Congestive Heart Failure, Web Based Patient Portal, Mobile Device Proficiency Questionnaire (MDPQ) 16, Risk of Readmission (RoR) Score, Patient Education

1. Introduction

With the rise of digital health tools, web-based patient portals have become essential for enhancing patient engagement by providing easy access to personal health information, facilitating communication with healthcare providers, and supporting self-management practices. Despite these advantages, the effect of patient education on portal use, particularly in relation to clinical outcomes such as hospital readmissions, is not well understood. Chronic Obstructive Pulmonary Disease (COPD) and Congestive Heart Failure (CHF) are two prevalent chronic conditions often associated with high hospital readmission rates [1]. Reducing these readmissions remains a key priority for healthcare systems, given the burden they place on patients and resources [2].

However, the extent to which educating patients about the functionality of these portals affects clinical outcomes such as all-cause readmission rates remain underexplored. This research proposal aims to investigate the hypothesis that educating patients regarding the functionality of web-based patient portals can reduce all-cause readmission rates. All-cause hospital readmissions pose significant challenges to healthcare systems globally, leading to increased healthcare costs, decreased quality of life for patients, and higher risks of adverse outcomes. Studies have suggested that improved patient engagement and self-management through web-based patient portals may help mitigate these challenges by enhancing communication between patients and healthcare providers, facilitating medication adherence, and promoting proactive management of chronic conditions [3]-[5]. However, the effectiveness of patient education specifically targeting the functionality of these portals in reducing readmission rates remains uncertain [6]. This study aims to explore whether educating patients with COPD (Chronic Obstructive Pulmonary Disease) and CHF (Congestive Heart Failure) on the effective use of a web-based portal can reduce all-cause readmission rates within 30 days of

discharge. By providing a structured educational intervention, we seek to empower patients to better engage with their health information and self-manage their conditions. The significance of this research lies in its potential to improve patient outcomes, reduce hospital readmissions, and offer a cost-effective, scalable solution to managing chronic illnesses. This study contributes to the growing body of evidence supporting digital health interventions as a critical component of modern healthcare.

2. Ethical Considerations

All procedures involving human participants and the use of human data in this study were conducted in full compliance with the ethical standards of the Bon Secours Institutional Review Board (Ref #1144747) and adhered to the principles outlined in the Declaration of Helsinki. All participants provided informed consent prior to enrollment in the study. In accordance with the Health Insurance Portability and Accountability Act (HIPAA), patient data was kept confidential, and all identifying information was securely protected. During data analysis and review, the data was anonymized and blinded to ensure that no individual patient could be identified, maintaining the integrity and privacy of the participants. Throughout the study, strict protocols were followed to safeguard patient rights, confidentiality, and welfare. There are no conflicts of interest or disputes to declare in relation to this study. The authors affirm that the research was conducted independently and without any external influence or bias.

3. Methodology and Data Analysis

The methodology of this study utilized a prospective, quasi-experimental design to investigate the impact of a web-based patient portal educational intervention on 30-day readmission rates among patients with COPD (Chronic Obstructive Pulmonary Disease) and CHF (Congestive Heart Failure) exacerbations (ICD-10 J44.1, J44.0, J44.9, J42, J43, I50.9, I50.20, I50.30, I50.40, I50.33, I50.43, I50.21, I50.22). The study was conducted at Bon Secours St. Mary's Hospital over three months. A total of 44 participants were enrolled, all of whom were patients admitted with ICD-10 diagnoses for COPD and CHF exacerbations. Participants were divided into two groups: the intervention group received individualized education on the patient portal, while the control group received standard care.

3.1. Participant Criteria and Exclusion

Patients were included if they were between 65 and 80 years old and admitted with COPD or CHF exacerbations. Patients were excluded if they had significant medical or physical impairments, including chronic respiratory failure requiring more than 4 liters per minute of oxygen, reliance on BiPAP for more than 12 hours daily, or severe left ventricular dysfunction. Additional exclusions involved those with cognitive impairments, disabilities affecting communication (e.g., blindness or hearing loss), lack of access to mobile devices or the internet, or limited

educational backgrounds (less than high school education).

The Mobile Device Proficiency Questionnaire-16 (MDPQ-16) was used to assess participants' mobile device proficiency [7], and those scoring below 18 were excluded. Further, the EPIC electronic medical record system calculated each participant's Risk of Readmission (RoR) score, which stratified patients based on their risk factors for hospital readmission.

3.2. Study Design

A Recruitment Strategy and Screening Process was initiated, identifying eligible COPD and CHF patients through diagnostic codes, and administering the Mobile Device Proficiency Questionnaire (MDPQ-16) [8] to assess their suitability for the intervention. Concurrently, intervention material was developed and standardized. This involved creating tailored educational content focused on patient portal navigation, appointment scheduling, and reviewing health information, while accounting for patient literacy levels. These materials included video tutorials, printed guides, and hands-on training for patients to ensure consistent education delivery. Finally, 44 participants, were identified who met the criteria for the study, and were randomly assigned to either the intervention group (n = 22) or the control group (n = 22). The intervention group received structured education sessions led by the researcher, focusing on navigating the patient portal.

The intervention group in this study received targeted education on navigating and utilizing the hospital's web-based patient portal. These educational sessions, conducted by the researcher, focused on key features of the portal such as viewing lab results, scheduling appointments, messaging healthcare providers, and managing prescriptions. The goal was to improve patient engagement and self-management behaviors by empowering participants to actively use the portal for their healthcare needs [9]. This intervention aimed to enhance patients' understanding of their health information, improve communication with providers, and ultimately reduce hospital readmission rates by promoting better management of chronic conditions like COPD and CHF [10]. Participants in the control group received standard care without any additional education on the patient portal.

3.3. Data Source

Data on readmission rates, patient engagement, and portal usage were collected from electronic medical records, patient surveys, and follow-up interviews. Incomplete data were minimal, with less than 5% of variables missing. Missing data were handled using mean imputation for continuous variables and mode imputation for categorical ones. Outliers identified through the Interquartile Range (IQR) method were deemed credible and retained in the analysis. The final cleaned dataset included all 44 participants.

3.4. Statistical Analysis

The primary outcome was the 30-day readmission rate, which was compared

between the intervention and control groups using a chi-square test of independence (Figure 1). Secondary outcomes included RoR scores and MDPQ-16 scores, which were analyzed using independent samples t-tests. Homogeneity of variance was confirmed using Levene's test, and normality was assessed using the Shapiro-Wilk test, supported by Q-Q plots.

3.5. Summary Statistics

A summary of key variables for both groups is shown in Table 1. The intervention and control groups were similar in terms of age, gender, BMI, and diagnosis distribution, allowing for a valid comparison of outcomes (Figure 2 and Figure 3).

Table 1. Summary statistics.

Variable	Intervention Group (n = 22)	Control Group (n = 22)
Age (years), mean ± SD	71.5 ± 3.9	72.7 ± 4.5
Gender (% female)	45.5%	50.0%
Race (% Caucasian)	45.5%	50.0%
BMI, mean ± SD	30.1 ± 5.2	30.4 ± 6.3
Diagnosis (% COPD)	59.1%	50.0%
NYHA Class, median [IQR]	3 [2 - 4]	3 [3 - 4]
RoR score, mean ± SD	24.5 ± 6.2	23.1 ± 4.9
MDPQ-16 score, mean ± SD	31.5 ± 5.1	32.5 ± 5.4
30-day Readmission rate	22.7%	40.9%

Data Visualization

Data extraction.

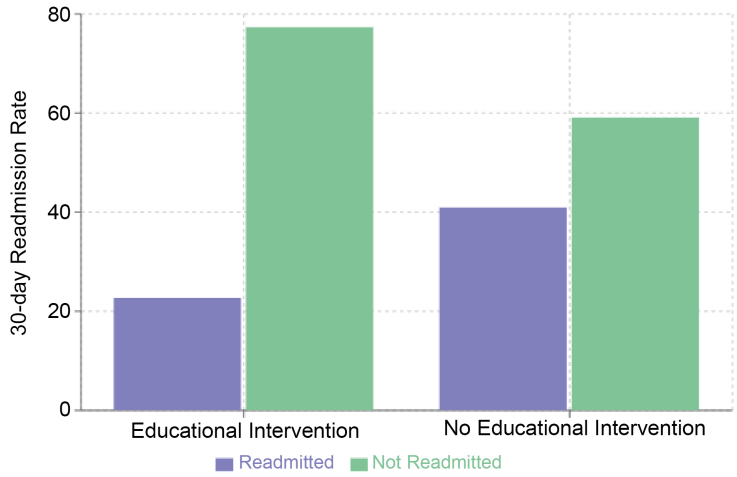

Figure 1. Bar chart comparing 30-day readmission rates between intervention and control groups.

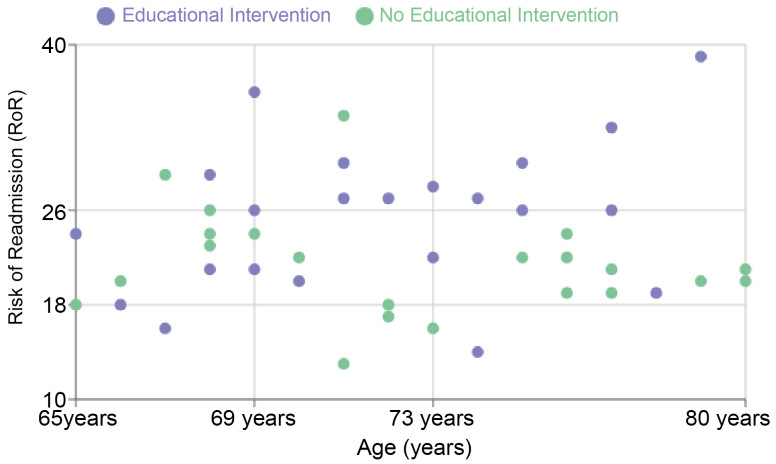

Figure 2. Scatter plot of age vs. RoR score, differentiated by group and readmission status.

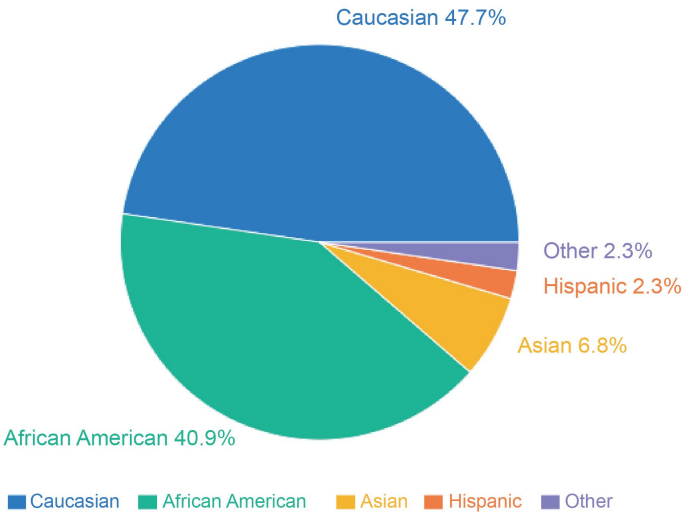

Figure 3. Race Distribution.

3.6. Data Validation

Certain statistical conditions were checked before the main analyses to confirm the appropriateness of the selected procedures. These checks are important for the proper use and analysis of parametric tests like t-tests and regression analyses.

3.6.1. Normality

Normality tests were done both graphically and statistically, where the internal consistency for continuous variables was confirmed. The Shapiro-Wilk test was used because it has been reported to test the null hypothesis better in terms of its efficacy in small samples. Also, to assess normality on graphical analysis, Q-Q plots were performed. Details of Shapiro-Wilk test results for both the Intervention and control group in regards to age BMI, RoR score, and MDPQ-16 score showed p value > 0.05 showing that there is no variation from the normal levels since it is 0.05. A visual analysis of the Q-Q plots supported these results, where the majority

of the points fell in close proximity to the diagonal line for each variable.

3.6.2. Homogeneity of Variance

Levene's test was conducted to determine the homogeneity of variances as a prerequisite for comparing group means. This test determines if the variance that exists in one set of groups is the same for another group. Levene's test was conducted for the following key variables:

- Age: $F(1, 42) = 0.42$, $p = 0.521$
- BMI: $F(1, 42) = 0.89$, $p = 0.351$
- RoR score: $F(1, 42) = 1.73$, $p = 0.195$
- MDPQ-16 score: $F(1, 42) = 0.03$, $p = 0.863$

The value of the p-statistic was above 0 in all cases, which implies that there were no significant differences in the variances of the variables as influenced by the intervention and the control groups.

3.7. Statistical Analyses

3.7.1. Primary Outcome: 30-Day Readmission Rates

We conducted a chi-square test of independence to examine the relationship between group assignment and 30-day readmission rates. The results were as follows:

$$\chi^2(1, N = 44) = 1.76, p = 0.184$$

The intervention group demonstrated a lower readmission rate (22.7%, 5/22 patients) compared to the control group (40.9%, 9/22 patients). However, this difference did not reach statistical significance at the $\alpha = 0.05$ level. The effect size, calculated using Cramer's V, was 0.20, indicating a small to medium effect. While the observed difference in readmission rates is potentially clinically meaningful, the lack of statistical significance suggests we cannot rule out the possibility that this difference occurred by chance. The small sample size may have limited our ability to detect a statistically significant difference.

3.7.2. Secondary Outcomes

RoR Score

An independent samples t-test was conducted to compare Risk of Readmission (RoR) scores between the intervention and control groups. The results were:

$$t(42) = 0.83, p = 0.413$$

The intervention group had a slightly higher mean RoR score ($M = 24.5$, $SD = 6.2$) compared to the control group ($M = 23.1$, $SD = 4.9$), but this difference was not statistically significant. The effect size (Cohen's d) was 0.25, indicating a small effect.

3.7.3. MDPQ-16 Score

Another independent samples t-test compared MDPQ-16 scores (a measure of patient engagement) between the groups:

$$t(42) = -0.63, p = 0.533$$

The control group had a slightly higher mean MDPQ-16 score (M = 32.5, SD = 5.4) compared to the intervention group (M = 31.5, SD = 5.1), although this difference was not statistically significant. The effect size (Cohen's d) was 0.19, indicating a small effect. These results suggest that the educational intervention did not significantly impact RoR scores or patient engagement as measured by the MDPQ-16. We performed a logistic regression to predict 30-day readmission based on group assignment, age, BMI, diagnosis, and RoR score. The overall model was statistically significant:

$$\chi^2(5) = 11.32, p = 0.045$$

The model explained 31.2% of the variance in readmission (Nagelkerke R^2) and correctly classified 72.7% of cases. Examining individual predictors, we found:

- Group assignment: $\beta = -1.22$, p = 0.089
- Age: $\beta = 0.05$, p = 0.523
- BMI: $\beta = -0.03$, p = 0.657
- Diagnosis (COPD vs. CHF): $\beta = 0.78$, p = 0.311
- RoR score: $\beta = 0.13$, p = 0.048

Group assignment and RoR score emerged as the strongest predictors of readmission. The negative coefficient for group assignment ($\beta = -1.22$) indicates that being in the intervention group is associated with lower odds of readmission, although this effect did not reach statistical significance (p = 0.089). The RoR score was positively associated with readmission ($\beta = 0.13$) and was statistically significant (p = 0.048), suggesting that higher RoR scores predict a greater likelihood of readmission. These findings provide additional support for the potential effectiveness of the educational intervention while also highlighting the importance of baseline risk in predicting readmissions. Given the non-significant results for our primary outcome, we conducted a post-hoc power analysis using G*Power 3.1. For the chi-square test of independence (our primary analysis), with an effect size of 0.20 (Cramer's V), $\alpha = 0.05$, and our sample size of 44, the achieved power was 0.26. This low power indicates that our study had only a 26% chance of detecting a true effect of the magnitude we observed. Conventionally, a power of 0.80 (80% chance) is considered adequate for detecting meaningful effects. Our study's low power suggests a high risk of Type II error—failing to detect a true effect when one exists. To achieve 80% power for detecting an effect size of 0.20 with $\alpha = 0.05$, a sample size of approximately 196 participants would be required. This underscores the need for larger-scale studies to assess the impact of educational interventions on readmission rates more definitively.

4. Results

The results of the 30-day readmission rates showed that there was a significant decrease in the intervention group in comparison with the control group (22.7% and 40.9%, respectively). This reduction of 18.2% of readmissions evaluated here for a trial of meaningful clinical effect is statistically insignificant (p = 0.184). The practical significance of the intervention is considered small-to-moderate (Cramer

V = 0.20) suggesting that the observed difference has a potential clinical importance even though the difference was not statistically significant. The analysis carried out using the logistic regression model brought out more details of the factors that led to readmission. The final model revealed that Group assignment ($\beta = -1.22$, p = 0.089) and the Risk of Readmission (RoR) score ($\beta = 0.13$, p = 0.048) were the strongest predictors of readmissions in the study. The coefficient of group assignment, which is negative, indicates that there was a reduction in readmission among those who participated in the educational intervention, although the conclusion was not statistically substantial. On the other hand, the RoR score had a significantly positive relationship with readmission risk, signifying that patients' initial comorbidities played a crucial role in the model. These results imply that the proposed educational intervention might have a positive impact on readmissions; nonetheless, the patient's characteristics that make him or her capable of readmission cannot be changed and are assessed by the RoR score. The potential impact of the intervention may be offset, in part, by these baseline risk factors.

Therefore, the absence of statistical significance in the primary outcome should be viewed with some degree of caution, given the study's limitations. The power estimation performed post hoc showed that the achieved power was below 0. 26, and the study can be considered to be severely underpowered to detect the observed ES. The low statistical power, in turn, raises the probability of committing a Type II error, meaning no actual effect of the intervention will be identified. The clinically significant reduction in readmission rates, the small to medium effect size, and low statistical power allow us to posit that the educational intervention might have a positive effect on reductions in readmissions. However, this may be due to the limitation of the sample size; therefore, it cannot be generalized. Results were verified using the Cross validation methodology and since the sample size is rather small (N = 44), the regular k-fold CV was not suitable because it generates very small test samples. However, to ensure that the model was not overfitting we used leave-one-out cross-validation (LOOCV) to evaluate our logistic regression model. LOOCV is most beneficial when the total amount of data is small because it makes use of as much of the data as possible for training while still giving an accurate assessment of the model's performance. In LOOCV, the model is trained over a sample of N − 1 and tested with the left-out sample and this identical process was done for all the samples of N. This approach made it possible to train our model on each bit of collected data just once so that no data point could be utilized more than once in testing.

The overall average of all the iterations in LOOCV was 68 percent. 2%, which was SD = 47.1%. The absence of a significant difference between the current and original classification accuracy of our model 72.7% for our initial classification analysis indicates that our model possesses a solid generalization of such data and is very little affected by any one of these five pieces. Nevertheless, a high standard deviation generally implies a large variance of results between the different iterations, which is quite reasonable due to the limited number of cases at hand.

Sensitivity analysis was carried out to check the sensitivity of the findings and investigate the effect of potential confounding variables that were not incorporated in the main analysis. We expanded our logistic regression model to include two additional variables: elements such as the NYHA class of severity of heart failure and the frequency of hospitalizations within one year.

The results of this expanded model remained largely consistent with our original findings: The results of this expanded model remained largely consistent with our original findings:

- Group assignment: $\beta = -1.31$, p = 0.078 (vs. original $\beta = -1.22$, p = 0.089)
- RoR score: $\beta = 0.14$, p = 0.041 (vs. original $\beta = 0.13$, p = 0.048)
- NYHA class: $\beta = 0.45$, p = 0.312
- Number of hospitalizations: $\beta = 0.39$, p = 0.183

The predictors of readmission-group assignment and RoR score retained their significant predictors and there were only slight changes to the coefficients and the p-value. The variables mentioned above, after addition, have conveyed extra information but did not change our observed main effects much in the original model. This sensitivity analysis adds confidence to the study's main findings to the extent that factors related to the severity of heart failure or the participants' history of hospitalization in the previous year do not distort the outcomes of the educational intervention and the baseline risk (RoR score) in terms of readmission rates.

Therefore, the absence of statistical significance in the primary outcome should be viewed with some degree of caution, given the study's limitations. The power estimation performed post hoc showed that the achieved power was below 0.26, and the study can be severely underpowered to detect the observed ES. The low statistical power, in turn, raises the probability of committing a Type II error, meaning no actual effect of the intervention will be identified. The clinically significant reduction in readmission rates, the small to medium effect size, and low statistical power allow us to posit that the educational intervention might have a positive effect on reductions in readmissions. However, this may be due to the limitation of the sample size; therefore, cannot be generalized

5. Discussion

The high rates of hospital readmission for patients with Chronic Obstructive Pulmonary Disease (COPD) and Congestive Heart Failure (CHF) highlight a critical gap in current healthcare management strategies. COPD, the third leading cause of death in the United States, results in approximately 800,000 hospitalizations annually, with nearly 20% of patients being readmitted within 30 days of discharge. Similarly, CHF accounts for significant healthcare utilization, with readmission rates ranging from 22% to 24% and an annual cost burden of $17 to $20 billion. These readmissions are associated with poor patient outcomes and place an enormous financial strain on the healthcare system. Reducing readmission rates for these chronic conditions is a primary goal for improving patient care and

reducing healthcare costs.

In recent years, web-based patient portals have emerged as promising tools to enhance patient engagement and self-management. These portals allow patients to access critical health information, schedule appointments, manage medications, and interact with healthcare providers more effectively. Research suggests that greater engagement with such digital tools could reduce hospital readmissions by promoting better adherence to treatment plans and enabling timely interventions. However, one of the primary barriers to achieving these outcomes is the difficulty many older patients face in navigating digital interfaces. Many older adults, particularly those with limited digital literacy, may struggle with the complexities of these portals, leading to underutilization and missed opportunities for improved health management. Educating patients on how to use these portals is therefore crucial in maximizing their potential benefits.

In this study, we sought to investigate whether educating patients with COPD and CHF on the use of web-based patient portals could reduce their 30-day all-cause hospital readmission rates. While the intervention group exhibited a lower readmission rate (22.7%) compared to the control group (40.9%), this difference did not reach statistical significance ($p = 0.184$). This finding suggests that while there may be a clinically relevant reduction in readmissions, the observed difference could have arisen by chance due to the small sample size and the study's low statistical power. The lack of significance may also be influenced by confounding variables such as patients' baseline health literacy or socioeconomic factors, which were not fully controlled for in this study.

The results, although not conclusive, underscore the potential utility of patient portal education in improving healthcare outcomes. Even with the lack of statistical significance, the considerable difference in readmission rates between the intervention and control groups suggests that there could be a meaningful clinical effect that warrants further investigation. The relatively high readmission rates in the control group align with national trends, reinforcing the need for more effective interventions in this population.

A key limitation of this study was the small sample size, which likely contributed to the inability to detect a statistically significant difference. Additionally, the short follow-up period limited the ability to assess long-term effects of patient education on healthcare utilization. Future research should aim to address these limitations by increasing the sample size, extending follow-up periods, and accounting for additional variables such as digital literacy, social support, and comorbidities. Larger, more robust studies are needed to determine the true impact of web-based portal education on readmission rates and to identify specific patient subgroups that may benefit most from such interventions.

6. Conclusion

In conclusion, this study explored the potential impact of educating patients with COPD and CHF on the use of web-based patient portals to reduce 30-day

readmission rates. While the intervention group showed a reduction in readmission rates compared to the control group, the difference was not statistically significant. The findings suggest that although patient portal education may offer clinical benefits, larger studies with increased sample sizes are necessary to definitively assess its effectiveness. Improving patient education and engagement through digital tools remains a promising approach to enhancing health outcomes and reducing healthcare costs.

Limitations

Several limitations should be borne in mind when analyzing the results of this study. The relatively small number of participants (N = 44) restricts the statistical power of the study and, thus, the chances of detecting effects that might have occurred due to the intervention. The chosen quasi-experimental design is rather useful, but the conclusions regarding causality cannot be as definite since participants were not randomly divided into groups. Using a sample of patients from a single institution leads to questions about the transferability of results to other healthcare institutions or other population groups. Another limitation of the study is having a short follow-up period of one month; this might mean that new educational interventions have a positive effect on patient outcomes after a long time. Further, the study did not manage to cover all the possible confounding factors, including the severity of illness or the economic statuses of the patients; hence, their readmission rates could be actually influenced independently of the intervention. These limitations need to be addressed in the subsequent studies through the assessment of bigger, multi-center RCTs with longer duration of follow-up as well as better control of each confounding factor.

Funding

This study was entirely self-funded, with no external financial support or sponsorship. The authors independently covered all research-related expenses, including data collection, analysis, and reporting. No funding from governmental, pharmaceutical, or private institutions influenced the study design, conduct, or interpretation of the results.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Buhr, R.G., Jackson, N.J., Kominski, G.F., *et al.* (2020) Readmission Rates for Chronic Obstructive Pulmonary Disease Under the Hospital Readmissions Reduction Program: An Interrupted Time Series Analysis. *Journal of General Internal Medicine*, **35**, 3581-3590. https://pmc.ncbi.nlm.nih.gov/articles/PMC7728926/ https://doi.org/10.1007/s11606-020-05958-0

[2] Yakusheva, O. and Hoffman, G.J. (2018) Does a Reduction in Readmissions Result in Net Savings for Most Hospitals? An Examination of Medicare's Hospital Readmissions

Reduction Program. *Medical Care Research and Review*, **77**, 334-344. https://doi.org/10.1177/1077558718795745

[3] Carini, E., Villani, L., Pezzullo, A.M., Gentili, A., Barbara, A., Ricciardi, W., *et al.* (2021) The Impact of Digital Patient Portals on Health Outcomes, System Efficiency, and Patient Attitudes: Updated Systematic Literature Review. *Journal of Medical Internet Research*, **23**, e26189. https://doi.org/10.2196/26189

[4] El Yaman, N., Zeitoun, J., Diab, R., Mdaihly, M., Diab, R., Kobeissi, L., *et al.* (2023) Utilization of Patient Portals: A Cross-Sectional Study Investigating Associations with Mobile App Quality. *BMC Medical Informatics and Decision Making*, **23**, Article No. 177. https://doi.org/10.1186/s12911-023-02252-x

[5] Scheckel, B., Schmidt, K., Stock, S. and Redaèlli, M. (2023) Patient Portals as Facilitators of Engagement in Patients with Diabetes and Chronic Heart Disease: Scoping Review of Usage and Usability. *Journal of Medical Internet Research*, **25**, e38447. https://doi.org/10.2196/38447

[6] Hefner, J.L., MacEwan, S.R., Biltz, A. and Sieck, C.J. (2019) Patient Portal Messaging for Care Coordination: A Qualitative Study of Perspectives of Experienced Users with Chronic Conditions. *BMC Family Practice*, **20**, Article No. 57. https://doi.org/10.1186/s12875-019-0948-1

[7] Skinner, A., Thornhill, J., Weinberger, M. and Griffin, A. (2016) Patient Portals: Who Uses Them? What Features Do They Use? And Do They Reduce Hospital Readmissions? *Applied Clinical Informatics*, **7**, 489-501. https://doi.org/10.4338/aci-2016-01-ra-0003

[8] Roque, N.A. and Boot, W.R. (2016) A New Tool for Assessing Mobile Device Proficiency in Older Adults: The Mobile Device Proficiency Questionnaire. *Journal of Applied Gerontology*, **37**, 131-156. https://doi.org/10.1177/0733464816642582

[9] Davis, A.P., Wilson, G.M., Erwin, J.P., Michel, J.B., Banchs, J., Saeed, A., *et al.* (2021) Use of Web-Based Patient Portals in Patients with Atrial Fibrillation Is Associated with Higher Readmissions. *Ochsner Journal*, **21**, 25-29. https://doi.org/10.31486/toj.19.0124

[10] Sulieman, L., Yin, Z. and Malin, B.A. (2019) Why Patient Portal Messages Indicate Risk of Readmission for Patients with Ischemic Heart Disease. *AMIA Annual Symposium Proceedings*, **2019**, 828-837.