Evaluation of the effectiveness of personal electronic health assistants in monitoring patients with chronic diseases

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Abstract

Introduction: Chronic diseases pose significant challenges in healthcare, which has driven the development of electronic health solutions. The effectiveness of these solutions in the management of diseases such as hypertension has generated interest, but further in-depth, evidence-based evaluation is required.

Objective: The study aims to comprehensively evaluate how a customizable web platform, called "HyperVigilance", influences blood pressure control in hypertensive patients, considering additional variables such as patient satisfaction, quality of life and costs associated with treatment. In addition, the aim is to explore possible demographic factors that could moderate the results.

Methodology: The study was conducted with a quasi-experimental research design that included an intervention group using the "HyperVigilance" platform and a control group receiving standard medical care. Statistical tests were applied and demographic factors such as age, gender and socioeconomic status were considered.

Results: The use of the "HyperVigilance" platform resulted in a significant reduction in blood pressure, increased patient satisfaction and a marked improvement in quality of life, as well as a reduction in the costs associated with the treatment of hypertension.

Conclusions: The study concludes that the "HyperVigilance" platform is effective in controlling blood pressure and improving quality of life in patients with hypertension. The results support the growing role of digital interventions in chronic disease management, but highlight the need for long-term studies and exploration of different populations for a more complete understanding of their impact.

Keywords: Hypertension, Personal electronic health assistants, HyperVigilance Platform, Quality of life, Associated costs.

Received on 17 March 2023, accepted on 21 October 2023, published on 24 October 2023

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doi: 10.4108/eetpht.9.4215

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1. Introduction

Chronic diseases represent one of the most pressing challenges to global health today [1-8]. These conditions, which include diseases such as diabetes, hypertension, and cardiovascular disease, require continuous monitoring and effective management to prevent serious complications and improve patients’ quality of life [9-13]. However, traditional monitoring of chronic diseases often has limitations in terms of accessibility, efficacy and cost [14-19], which has prompted the search for innovative approaches to improve patient care and self-care [20-24].

In this context, electronic health tools, or eHealth, have emerged as a promising solution for addressing the challenges associated with chronic disease [25-27]. These tools, which include mobile applications, customizable web platforms, and electronic personal health assistants [28-30], have the potential to overcome traditional barriers by providing more accessible support, real-time information [31-34] and personalized follow-up tools [35-38]. As technology continues to advance, the question arises as to whether these digital solutions can really make a difference in the lives of patients with chronic diseases [39-42].

While research in eHealth has yielded promising results in terms of improvements in treatment adherence and management of diseases such as diabetes [43-45], there is still a critical need for rigorous, evidence-based evaluations [46-49]. The evidence on the actual impact of eHealth tools on concrete clinical outcomes, such as blood pressure control in hypertensive patients, is mixed [50-53] and requires further investigation.

The fundamental objective of this study is to address this knowledge gap by comprehensively assessing how the use of a customizable web-based platform, called "HyperVigilance,” influences blood pressure control in patients diagnosed with hypertension. In addition to blood pressure control, this study will analyze additional variables, such as satisfaction with care received, perceived quality of life, and costs associated with treatment. Demographic factors, such as age, gender, educational level, and socioeconomic status, will also be explored to better understand how these aspects may influence the effectiveness of eHealth interventions.

This original study has the potential to shed light on the impact of digital tools in chronic disease management, which could revolutionize the way patients and healthcare professionals approach these conditions. The results can not only inform clinical decision-making and the design of more effective care strategies, but also contribute to the growing field of eHealth and its role in improving healthcare and quality of life for patients.

2. Methods

Research Design

A quasi-experimental research design with comparative groups was used to evaluate the effects of the intervention on blood pressure control and other variables of interest. This design allowed consideration of demographic factors by stratifying the sample.

Population and Sample

The target population of the study consisted of hypertensive patients attending the East Primary Care Center. The inclusion criteria for participants were as follows: being aged between 18 and 65 years, having been diagnosed with hypertension for more than 6 months and not presenting, other diseases that could affect the results of the study. The sample size was calculated using the difference of proportions formula, considering 80% power and a confidence level of 95%.

Recruitment and consent

Potential participants who met the inclusion criteria were contacted and provided with a detailed explanation of the study. Subsequently, their informed consent or approval to participate in the study was requested, ensuring that they were fully informed and voluntarily consented to participate in the research.

Sampling

Stratified random sampling was carried out considering the factors of sex and age (under 50 years and 50 years or older). Then, each stratum was randomly assigned to one of two groups: the intervention group or the control group.

Intervention

The experimental group had access to the “HyperVigilance” platform for a period of 6 months. This web platform designed for the study allowed participants the following:

- Register and log in using a personal username and password.
- Monitor your blood pressure on a weekly basis using a Bluetooth digital blood pressure monitor connected to your account.
- Daily record of antidiabetic and antihypertensive medication consumed.
- Access informative content on lifestyle modifications recommended for hypertensive patients.
- Receive weekly email reminders about the importance of adherence to treatment.
- Redeem points accumulated through monitoring and registration for vouchers for healthy eating courses.

On the other hand, the control group continued to receive the usual medical care at the clinic following local protocols for the treatment of hypertension.

Variables and Measurements

The main variables measured in this study include:
Blood Pressure: Blood pressure readings were recorded before and after the intervention, as well as at 3 months after the intervention.

Satisfaction: Participants' satisfaction with the medical care received was assessed using a validated Likert scale.

Quality of Life: The validated health-related quality of life (HRQoL) questionnaire was used to assess the impact of hypertension and the intervention on perceived quality of life.

Costs: Data were collected on the direct and indirect costs associated with the treatment of hypertension.

**Instruments**

Validated digital blood pressure monitors were used to measure blood pressure, and validated Likert and HRQoL questionnaires were applied to assess satisfaction and quality of life, respectively.

**Statistical Analysis**

To analyze the data, analysis of variance (ANOVA), nonparametric tests (such as the Wilcoxon test) and moderation analysis (using logistic regression) were performed. These analyses were performed using SPSS 29.0 statistical software.

**Ethical Considerations:**

The study received approval from the University ethics committee and informed consent was obtained from all participants prior to their participation in the study.

## 3. Results

**Effect of the HyperVigilance Platform on the Control of Blood Pressure.**

To assess the impact of the HyperVigilance platform on blood pressure control, blood pressure readings were recorded at three different time points: before the intervention, after the intervention, and at 3 months post-intervention. The results are summarized in Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
<th>Median</th>
<th>IQ Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA pre-intervention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention (N=50)</td>
<td>140.25 mmHg (7.12)</td>
<td>140 (10)</td>
<td>8</td>
</tr>
<tr>
<td>Control (N=50)</td>
<td>140.50 mmHg (6.98)</td>
<td>141 (10)</td>
<td>7</td>
</tr>
<tr>
<td>PA post-intervention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention (N=50)</td>
<td>130.75 mmHg (6.34)</td>
<td>130 (7)</td>
<td>7</td>
</tr>
<tr>
<td>Control (N=50)</td>
<td>139.75 mmHg (7.21)</td>
<td>140 (8)</td>
<td>9</td>
</tr>
<tr>
<td>PA 3 months later</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention (N=50)</td>
<td>138.25 mmHg (5.86)</td>
<td>138 (6)</td>
<td>6</td>
</tr>
<tr>
<td>Control (N=50)</td>
<td>139.00 mmHg (7.50)</td>
<td>139 (7)</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Table 1 presents a clear summary of the changes in participants' blood pressure throughout the study. At baseline, no significant differences in blood pressure readings were found between the Intervention group (140.25 mmHg) and the Control group (140.50 mmHg). However, after the intervention, the Intervention group showed a considerable reduction in blood pressure, with a mean of 130.75 mmHg, compared to the Control group, which maintained a mean of 139.75 mmHg. This positive trend in the Intervention group was maintained at 3 months later, with a mean of 138.25 mmHg. These results suggest that the HyperVigilance intervention had a significant impact on blood pressure reduction, supporting the efficacy of this intervention in the management of arterial hypertension.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Wilcoxon statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA pre-intervention</td>
<td>Intervention vs Control</td>
<td>1240</td>
<td>0.872</td>
</tr>
<tr>
<td>PA post-intervention</td>
<td>Intervention vs Control</td>
<td>190</td>
<td>0.001</td>
</tr>
<tr>
<td>PA at 3 months</td>
<td>Intervention vs Control</td>
<td>420</td>
<td>0.042</td>
</tr>
</tbody>
</table>

In Table 2, Wilcoxon tests comparing blood pressure (BP) at different time points of the study between the Intervention and Control groups are summarized. In pre-intervention BP, no significant differences were observed between groups (p>0.05), suggesting initial comparability. However, post-intervention, significant differences were found, with a p-value of 0.001 (p<0.01), supporting the effectiveness of the intervention in reducing BP. At 3 months post-intervention, although the differences are smaller, they persist, with a p-value of 0.042 (p<0.05). These results indicate that the intervention had a sustained positive impact on BP over time.

**Participant Satisfaction and Quality of Life**
Participants’ satisfaction with the care received was assessed using a validated Likert scale. The results are presented in Table 3.

### Table 3. Satisfaction and Quality of Life

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction - Intervention</td>
<td>4.8 (0.6)</td>
<td>5</td>
</tr>
<tr>
<td>- Control</td>
<td>3.2 (1.1)</td>
<td>3</td>
</tr>
<tr>
<td>Wilcoxon W statistic</td>
<td>90</td>
<td>p = 0.01</td>
</tr>
</tbody>
</table>

This table 3 presents the results of the Wilcoxon test to evaluate satisfaction between the Intervention and Control groups. The data reveal a statistically significant difference in satisfaction between these groups. The Intervention group obtained a mean score of 4.8, with a median of 5, indicating a relatively high level of satisfaction. In contrast, the Control group obtained a mean score of 3.2, with a median of 3, reflecting a lower level of satisfaction. The Wilcoxon W statistic was 90, with a p-value of 0.01, confirming the significant difference in satisfaction between the groups. These findings suggest that the intervention had a positive impact on the satisfaction of participants in the Intervention group compared to the Control group.

### Table 4. Quality of Life Changes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention Group (N=50)</th>
<th>Control Group (N=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Quality of Life</td>
<td>60.2 ± 5.3</td>
<td>61.0 ± 5.1</td>
</tr>
<tr>
<td>Final Quality of Life</td>
<td>74.8 ± 6.2</td>
<td>62.2 ± 5.8</td>
</tr>
<tr>
<td>Change in Quality of Life</td>
<td>14.6 ± 4.1</td>
<td>1.2 ± 2.3</td>
</tr>
<tr>
<td>Cohen's d</td>
<td>3.15</td>
<td>0.26</td>
</tr>
<tr>
<td>Student's t statistic (p)</td>
<td>12.53 (0.001)</td>
<td>1.67 (0.12)</td>
</tr>
</tbody>
</table>

The findings in Table 4 reveal a significant improvement in the quality of life of the intervention group compared to the control group. An initial difference between the groups will be observed, with the intervention group showing a mean score of 60.2 ± 5.3 and the control group with 61.0 ± 5.1. After the intervention, the intervention group experienced a considerable change in quality of life, with an average final score of 74.8 ± 6.2, while the control group showed minimal change, with an average final score of 62.2 ± 5.8. Furthermore, the change in quality of life was significantly greater in the intervention group (14.6 ± 4.1) compared to the control group (1.2 ± 2.3). Both the "Cohen's d" value (3.15 for the intervention group and 0.26 for the control group) and the Student's t-test analysis (p<0.001) support the idea that the HyperVigilance intervention had a positive and significant impact on the quality of life of the participants in the intervention group.

### Costs Associated with the Treatment of Hypertension

Data were collected on the direct and indirect costs associated with the treatment of hypertension in both groups. The results are presented in Table 5.

### Table 5. Costs Associated with Hypertension Treatment

<table>
<thead>
<tr>
<th>Type of Cost</th>
<th>Intervention Group (N=50)</th>
<th>Control Group (N=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct costs (medication, consultations, echocardiograms)</td>
<td>$550</td>
<td>$725</td>
</tr>
<tr>
<td>Indirect costs (work incapacity, cardiac rehabilitation, acute complications)</td>
<td>$1,800</td>
<td>$3,500</td>
</tr>
<tr>
<td>Total annual costs</td>
<td>$2,300</td>
<td>$4,225</td>
</tr>
</tbody>
</table>

Table 5 shows a clear difference in the costs associated with the treatment of hypertension between the intervention group and the control group. A notable reduction in direct and indirect costs is observed in the intervention group compared to the control group.
to the control group. Direct costs, which include expenditures on medications, consultations, and echocardiograms, were $550 in the intervention group and $725 in the control group, indicating substantial savings in the intervention group. Likewise, indirect costs, such as work disability, cardiac rehabilitation, and acute complications, showed a marked decrease in the intervention group, totaling $1,800 compared with $3,500 in the control group. These results strongly suggest the potential of the e-health personal assistant platform in reducing costs associated with hypertension treatment, which could have important implications for both patients and the healthcare system in general.

**Demographic factors**

To complement the analysis of the effectiveness of the intervention, we evaluated in an exploratory manner whether there were possible demographic factors that could moderate these results. In particular, variables such as age, gender, presence of comorbidities and socioeconomic level of the participants were studied.

The findings of these preliminary tests are presented in Table 6, which summarizes the statistical analyses performed for each factor and subgroup considered. It should be noted that, given the exploratory nature of these tests, the results should be interpreted as an initial approximation of possible areas of moderating influence, and more comprehensive studies are required to strengthen any conclusions.

Nonetheless, these findings provide relevant information to guide further research into variables that could be associated with the heterogeneity of responses obtained with the intervention under study.

<table>
<thead>
<tr>
<th>Table 6. Exploratory analysis of possible demographic factors moderating intervention effectiveness</th>
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</thead>
<tbody>
<tr>
<td><strong>Moderator Factor</strong></td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Age</td>
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<tr>
<td></td>
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<tr>
<td>Genre</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Comorbidities</td>
</tr>
<tr>
<td>Cardiovascular</td>
</tr>
<tr>
<td>Socioeconomic level</td>
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<td></td>
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</table>

The results of the demographic factors presented in Table 6 provide valuable information on the relationship between demographic variables and the effectiveness of the intervention. In terms of age, having stratified the variable into two groups (≤50 years and >50 years), linear regression analyses performed on metric dependent variables showed no statistically significant differences between strata (p=0.125 and p=0.098 respectively). Similarly, binary logistic regression analyses applied to categorical outcome variables did not detect significant differences between the two age ranges. Regarding gender, both logistic regression analyses for men (p=0.212) and women (p=0.389) revealed no significant differences. When assessing comorbidities, no significant differences were found between the diabetes (p = 0.152) and cardiovascular disease (p = 0.124) subgroups in the mean comparison analyses. However, when considering socioeconomic level, significant differences were observed between strata 1-3 and strata 4-6 in the ANOVA analysis (p = 0.027 and p = 0.048, respectively). These results highlight the importance of socioeconomic level as an influential factor in the effectiveness of the intervention, while other demographic factors do not seem to have had a significant impact on the results of the study.

**4. Discussion**

The findings presented in this study provide fundamental insight into the positive impact of the "HyperVigilance" platform on blood pressure control, patient satisfaction, and costs associated with hypertension treatment [56-60]. The results consistently demonstrate a significant reduction in blood pressure among participants who used the platform compared to the control group. This evidence supports the effectiveness of the digital intervention in the management of hypertension and highlights its potential to improve health outcomes in patients with chronic disease [61-63]. In addition, it is crucial to mention the importance of conducting long-term follow-up studies to assess the sustainability of the benefits observed [64-68]. As indicated by Maddison et al. [69] in their study, this approach would allow a more complete understanding of how clinical, satisfaction, and economic outcomes are sustained over time, providing a more complete picture of the effectiveness and long-term impact of the "HyperVigilance" platform.

On the other hand, several promising lines of research emerging from this study are identified. Further analysis is recommended to understand the possible underlying mechanisms that explain how digital intervention translates into specific improvements in blood pressure and quality of life [70-73]. This approach would optimize the design of future strategies and improve the effectiveness of digital interventions in chronic disease management, as concluded.
by Bond et al. [74] after analyzing the behavioral determinants of adherence to mHealth applications through patient interviews. It is also proposed to apply the same methodological approach in different populations and settings to generalize the results on the impact of PHAs. This would provide a broader understanding of the effectiveness of the "HyperVigilance" platform and its applicability in various clinical and demographic settings [75]. In addition, it is suggested to explore mixed models that integrate digital intervention with face-to-face clinical support to maximize outcomes, especially considering the limitations of access to technology in some populations. This would address gaps in access to care and ensure more equitable implementation of eHealth solutions in different settings.

Finally, a formal evaluation of the cost-benefit ratio of the "HyperVigilance" platform with available conventional treatments is recommended. This analysis would provide a clearer understanding of the economic feasibility of large-scale implementation of the platform and its potential impact on chronic disease management in clinical and community settings.

5. Conclusions

In this quasi-experimental study, the effectiveness of the "HyperVigilance" platform in controlling blood pressure and improving quality of life in patients with hypertension was conclusively demonstrated. The internal validity of the quasi-experimental design provides a solid basis for establishing a causal relationship between the digital intervention and the observed changes in clinical outcomes. The results obtained are consistent with the growing evidence in the field of telemedicine/eHealth, which reinforces the relevance and potential of digital interventions in the management of chronic diseases.

The statistical analyses performed, including t-tests, ANOVA, and other methods, underscore the statistical significance of the observed changes in blood pressure, patient satisfaction, and costs associated with treatment. These findings strongly support the effectiveness of the "HyperVigilance" platform as a promising tool in the management of hypertension, offering clinically meaningful and economically feasible results.

It is important to recognize that these findings have significant practical implications for clinical care by providing an effective and accessible alternative in the management of hypertension and possibly other chronic diseases. However, we recognize the need to replicate this study in different clinical and demographic settings to generalize the results and confirm their applicability in a variety of health care settings.

A key limitation of this study lies in the lack of long-term follow-up groups, which limits a complete understanding of the long-term sustainability of the results obtained. Future research is highly encouraged to address this limitation and expand the understanding of the effectiveness and durability of the "HyperVigilance" platform in the ongoing management of hypertension and other chronic diseases.

References


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Tumiri T, Duran L, Lin J, Ríos NB, Mosca A, Gómez T. La Imagen de enfermería y simulación. Metaverse Basic and
Evaluation of the effectiveness of personal electronic health assistants in monitoring patients with chronic diseases


