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Cost-Consequences Analysis (CCA) of Virtual Reality and Robotic Rehabilitation Devices Integrated with a Home-Automation System for Patients with Neurological Diseases: Technology Developed at HosmartAI (HORIZON 2020 FUNDED)

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Background

- The recovery of motor function is a primary goal for individuals diagnosed with neurological diseases, such as Stroke, Parkinson's Disease, Multiple Sclerosis. Various rehabilitation methods have been used in neurorehabilitation hospitals, including conventional training and those involving technological devices.
- In addition to rehabilitation devices, such as robotic-assisted and virtual reality (VR) systems, the integration of home automation system may play a crucial role in monitoring and recording patient movements.
- In most cases, physiotherapy is performed at a 1:1 ratio [1 physiotherapist (PT): 1 patient]. The challenge was to introduce a new organizational model, in which a PT can treat more than one patient at the same time.

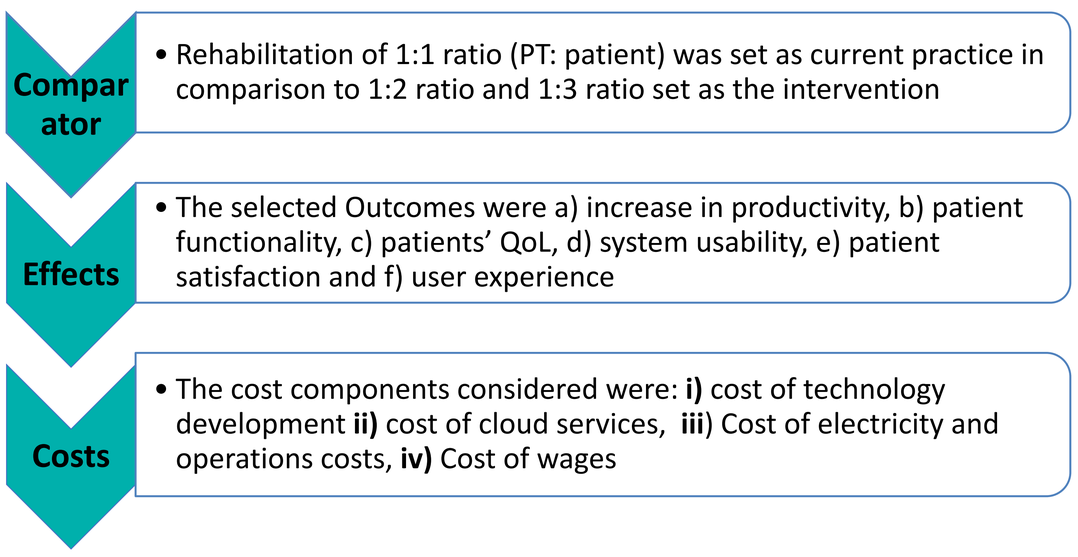
Objective

The study aimed to evaluate the economic and clinical performance of motor neurorehabilitation technologies by integrating VR and robotic rehabilitation devices with a home-automation system for group therapy (2-3 patients: 1 PT) in comparison to individual rehabilitation services (1 patient: 1 PT)

Methods

- 80 patients participated in the study at San Camillo IRCCS Hospital.
- Three organizational models were tested, and patients were assigned to one of them according to their characteristics, in particular their ability to manage rehabilitation with technological devices with sufficient independence:
  - Model 1: In the traditional setting a single PT is responsible for the treatment of a single patient.
  - Model 2: In the second organizational model, patients may be assigned to either a one-to-one traditional setting or a one-to-two group therapy.
  - Model 3: In the third organizational model, patients can be assigned to one-to-one traditional settings, one-to-two group therapy, or one-to-three group therapy.
- A micro-costing analysis was performed, based on the perspective of the Italian Healthcare System, to identify the following cost elements:
  - costs of development of the new AI technology,
  - cost of maintenance of the technology
  - cost of diagnosis and hospitalization of preterm births classified per birth weight and gestational age.
- The selected Key Performance Indicators (KPIs) of the new technology were a) increase in productivity, b) patient functionality, c) patients' quality of life (QoL), d) system usability , e) patient satisfaction and f) user experience.
- The comparison with the current practice (1:1 ratio) was performed incrementally (both costs and effects) to enable the cost-consequence analysis of Models 2 & 3.
- The chosen methodology was cost-consequence analysis (CCA) since it enables the presentation of various impacts of an intervention individually, rather than combining them into a single metric, This approach enables a more holistic understanding of the effects, while leaving it to the decision maker to determine the relative significance of each aspect (Figure 1).[1]

Figure 1. Components of costs and consequences in cost consequence analysis



Results

- Data collected from the whole sample (No. 80 patients) revealed promising results. Overall, significant clinical improvements were observed for all the clinical outcomes, except for the manual dexterity on the right side. Table 1 shows the clinical outcomes before (T0) and after (T1) treatment in the whole sample. The clinical outcomes are presented in Table 1.
- The level of QoL (i.e., EQ.5D score) reported by the patients statistically improved. Furthermore, the usability (i.e., SUS) demonstrated a good level of usability that improved after using the technological rehabilitation in the HosmartAI room. The level of user experience (i.e., UEQ) in the HosmartAI room improved for all outcomes, whereas the perception of the healthcare service (i.e., PSQ-18) did not show any changes from the baseline. Table 2 shows the PREM and PROM scores before (T0) and after (T1) treatment in the whole sample.

Results

Table 1. Clinical outcomes before (T0) and after (T1) treatment

All Patients (N=80)	Pre	Post	
Clinical Outcome	**T0 Mean (± SD)**	**T1 Mean (± SD)**	***P*-value**
Berg Balance Scale (BBS)	28 (± 19)	32 (± 19)	<0.001*
Trunk Control Test (TCT)	73 (± 30)	80 (± 26)	0.002*
10 meters walking test (10MWT)	0.39 (± 0.39)	0.50 (± 0.48)	<0.001*
Functional Ambulation Categories (FAC)	2 (± 2)	3 (± 2)	<0.001*
Box and Blocks (BBT), right	31 (± 17)	33 (± 19)	<0.001*
Box and Blocks (BBT), left	32 (± 17)	34 (± 18)	<0.001*
Nine Hole Peg Test (NHPT), right	0.37 (± 0.25)	0.38 (± 0.26)	0.182
Nine Hole Peg Test (NHPT), left	0.37 (± 0.23)	0.40 (± 0.23)	0.002*
Reaching Performance Scale (RPS), right	29 (± 11)	30 (± 10)	0.023*
Reaching Performance Scale (RPS), left	31 (± 11)	32 (± 10)	0.030*

- The results in terms of productivity were obtained without any significant differences in the clinical effectiveness of the therapies. Considering the total sample, the patients improved in all clinical outcome measures, especially for balance function and gait speed and capacity (i.e., they improved by 1 point more in the FAC scale). Moreover, post-hoc analysis confirmed that in each organizational model, the patients improved their functional level, with no significant differences among the three models.

Table 2. Patient Reported Experience Measure (PREM) and Patient Reported Outcomes Measures (PROMs) before (T0) and after (T1) treatment

All Patients (n=80)	Pre	Post	
PREM/PROM	**T0 Mean (± SD)**	**T1 Mean (± SD)**	***P*-value**
EQ-5D (vas)	54 (± 22)	65 (± 18)	0.001*
EQ-5D (time trade off)	20 (± 8)	0.57 (± 0.36)	0.001*
EQ-5D (vas score, tot)	0.50 (± 0.20)	18 (± 8)	0.001*
SUS	69 (± 13)	72 (± 14)	0.038*
PSQ-18 (General satisfaction)	6 (± 2)	6 (± 1)	0.775
PSQ-18 (Technical quality)	12 (± 2)	12 (± 2)	0.983
PSQ-18 (Interpersonal manner)	6 (± 2)	6 (± 1)	0.886
PSQ-18 (Communication)	6 (± 2)	6 (± 2)	0.859
PSQ-18 (Financial Aspect)	6 (± 1)	6 (± 1)	0.527
PSQ-18 (Time Spent with doctor)	6 (± 2)	6 (± 2)	0.162
PSQ-18 (Accessibility and Convenience)	12 (± 2)	12 (± 2)	0.468
UEQ (Attractiveness)	1.68 (± 1.12)	2.27 (± 0.82)	<0.001*
UEQ (Perspicuity)	1.51 (± 1.21)	2.08 (± 0.88)	<0.001*
UEQ (Efficiency)	1.18 (± 1.06)	1.84 (± 1.11)	<0.001*
UEQ (Dependability)	1.07 (± 1.26)	1.70 (± 1.12)	<0.001*
UEQ (Stimulation)	1.65 (± 1.03)	2.00 (± 1.09)	0.017*
UEQ - (Novelty)	1.75 (± 1.01)	2.03 (± 1.09)	0.0027*

- In Table 3, the results of the cost analysis are presented regarding the new neurorehabilitation device and the VIMAR domotic system, which were used at San Camillo IRCCS Hospital. The new technology seems to be a cost-saving option in the 1 physiotherapist – 2 and 3 patients' ratio, since it improves both productivity and provides economies of scale. More specifically, the per patient cost for Ratio 1 are €84,62, for Ratio 2 are €64,57 and for Ratio 3 are €57,33 per session, compared to the currently used technology of €74,89. Almost in all cases, HosmartAI technology is a cost-saving option with greater clinical results in all clinical parameters (motor and functional) as well as in patients' QoL and patient satisfaction.

Table 3. Cost Analysis of Ratio 1, 2 and 3

COST ANALYSIS OF ALL SCENARIOS					
Cost/Outcomes Categories	**Annual Cost**	**Technology Before HosmartAI (per patient cost)**	**HOSMARTAI Intervention (per patient cost with Ratio 1)**	**HOSMARTAI Intervention (per patient cost with Ratio2)**	**HOSMARTAI Intervention (per patient cost with Ratio3)**
Neurorehabilitation Devices (OAK, VRRS, AMADEO, PABLO)	38.954 €	54,10	54,10 €	45,09 €	41,62 €
Cloud Services	5.978 €	0,00	8,30 €	6,92 €	6,39 €
Vimar Domotic System	1.027 €	0,00	1,43 €	1,19 €	1,10 €
Electricity (per patient cost)	1,60 €	1,60	1,60 €	1,60 €	1,60 €
Operating Costs	362,84 €	0,50	0,50 €	0,42 €	0,39 €
Wages (Physiotherapist)	29.599 €	18,69	18,69 €	9,35 €	6,23 €
Total cost	75.923 €	74,89	84,62 €	64,57 €	57,33 €
Difference		**Baseline**	**9,73 €**	**-10 €**	**-18 €**

Conclusions

These promising findings validate the intervention's efficacy and broader impact on patient care and resource management. Further research is needed to understand the underlying mechanisms and optimize implementation.

References

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