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Economic Value Analysis of Gait Analysis Technology in the Field of Elderly Health

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Abstract:

There is a growth in population, and this implies that there is a better healthcare option needed to ensure that the older age population can live freely and reduce the cost of care. Falling is one of the major health issues of adults. Falls may result in injuries, hospitalization, long term disability and increased medical costs. Gait analysis technology study the gait of an individual not to mention whether one is on the verge of falling or not. This paper examines the utility of gait analysis technology in the adult health field. It will examine the ability of this technology to enhance outcomes in health and reduce expenditures. Knowing the walking style of a person, the physician can provide interventions such as therapy, balance, and medication to avoid falls, broken bones, among others. This technology of gait analysis may be quite helpful since it will lower the cost of care due to fewer falls that require care, surgery, or a long-term care, keep older adults active and independent, so the data does not require them to move to nursing homes, and the healthcare systems will also receive advantages. The paper also examines the expense of installing these systems such as the purchase of equipment, software, training employees and data management. Start-up may not be cheap, but it may save money in the long run through the elimination of hospital stays and institutional care. Gait analysis technology does not only involve saving money.

Keywords: Elderly health; Gait analysis; Rehabilitation retreatment

1. Introduction

In the current research, falls are any unintentional events that happen to community-based older adults and lead to the use of ground or a lower level to rest. This increased risk is linked to the age-related deterioration in balance control, muscle strength and the existence of multimorbidity. About 30% of people who are 65 or older and 50% of those who are 80 or older have at least one fall each year [1]. Besides causing injuries, falls can also create a fear of falling. This fear might make people avoid activities, which can make their bodies weaker over time and increase the chance of having more falls later.

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Falls and their aftereffects can lower quality of life for as long as nine months after the incident, demonstrating that older adults continue to face difficulties even beyond that period. It is well documented that the UK's National Health Service (NHS) incurs annual costs of approximately £4.4 billion related to fragility fractures, with hip fractures alone contributing over £2 billion in annual expenditures [2]. Beyond the direct costs to the healthcare system, additional expenses must be considered, including personal costs, informal care from family or friends, and lost productivity due to absences from work or unpaid responsibilities.

The main gait impairments are slow gait, excessive variability and loss of symmetry with severe consequences on the health of elderly. Eighty two percent of individuals above the age of 85 years have gait problems, which are usually due to bone, joint, or muscle problems These problems may be detected by carrying out structured clinical evaluations regarding mobility and balance. Contrary to younger individuals, in case of an older adult fall, it may result in severe damage to their health and reduce the quality of their life [3]. When such is experienced in an entire population, the financial and health expenditure of falls is of great concern to the health of the population.

These impairments may be frequently detected using systematic clinical evaluations of mobility and balance. To identify potential issues, the speed at which a person walks is an effective technique that can be used to notice potential issues, particularly, in the areas where people have to deal with falls and broken bones [4]. This type of work requires the cooperation of various agencies and organizations. The health and care groups and Risk of falling sessional engaged with people at risk are numerous. Through good governance, all these efforts ought to be structured and controlled effectively.

In the NHS trials, the GaitSmart (GAITSMART) system was used on older individuals who had either fallen or were largely or strongly afraid of falling and resided in community care environment. It involves an algorithm that forms detailed objective data that provides a clear evaluation of the capability of the patient to walk.

As the UK's population aged 60 and over continues to grow, the economic burden of falls among older adults has become an escalating concern for both public health officials and clinicians. Falls are a strong indicator of the need for long-term care, especially for those over 65, due to the high rate of falls and their impact [5]. To assess how effective the GAITSMART system is in the short and long term, an early economic evaluation was done [6]. This is helpful to understand the cost-benefit of using the GAITSMART system to improve movement and lower the rate of falls and fear of falling. Data on walking patterns and fear of falling to calculate the return on investment from using the GAITSMART system to cut down on the costs of caring for fall-related injuries was also used.

This article focuses on data-driven innovation in preventive healthcare. This approach uses real-time walking data along with psychological factors such as fear of falling, marking a new way of moving from treating problems after they occur to predicting and preventing them. This allows for early interventions, creating possibilities for smart monitoring tools, AI-based warnings, and tailored programs to improve mobility.

The combination of behavior and body movement creates considerable economic value. The assessment goes beyond physical results by connecting how people move with their mental aspects, like fear of falling, to determine the financial benefits. This new method is unique because it looks at cost-effectiveness not just in terms of medical results but also includes mental health and savings from long-term care, encouraging more complete and thoughtful healthcare approaches.

2. Methods

2.1 Study Design

To comprehensively evaluate the cost-effectiveness of the GAITSMART intervention relative to usual care among older adults who had experienced falls or moderate-to-severe fear of falling—particularly those residing in UK community care units—researchers developed a preliminary economic model (a decision-tree model) and a Return on Investment (ROI) measurement tool [7]. The analysis was conducted using the CHEERS 2022 reporting standards, which included perspective, time horizon, and analysis of uncertainty.

2.2 Study Population

The study concentrated on elderly individuals residing in a community care setting, who had either sustained falls or suffered from moderate to severe fear of falling. There were 117 participants on average, with an age of 79 years old, plus or minus 9.4 years [8]. Their average body mass index was 24.9, plus or minus 4.9. About 45.8% were men, and 54.2% were women, which shows a nearly equal split between the two genders.

2.3 Study Perspective

From the NHS perspective, the preliminary economic model and ROI tool were developed to assess whether the GAITSMART system offers better value for money compared to standard care for individuals with falls or moderate-to-severe fear of falling [9]. This evaluation followed the methodologies outlined by the National Institute for Health and Care Excellence (NICE) for evaluating emerging technologies.

2.4 Intervention and Comparator

The GAITSMART intervention was administered to the intervention group and contrasted with usual care. The GAITSMART is a sensor-based digital medical equipment (a CE Marked Class 1 Medical equipment Ltd.) that is used in clinical setting GaitSmart to assist elderly patients who have fallen or are at danger of falling, particularly those with varied degrees of frailty [10]. The GAITSMART provides a thorough and impartial evaluation of a patient's gait. Based on recognized biomechanical deficiencies, exercise recommendations were automatically created.

All of the suggested activities followed current best practices and were either taken from the Otago Exercise Program (OEP) or the NHS guidelines for older persons [11]. Because the OEP is so successful at avoiding falls, it is frequently employed. The GAITSMART only recommends workouts that address the particular deficits it identifies, which is the main distinction between it and the OEP and NHS guidelines. Clear, objective data that quantifies gait issues and aids in goal setting are provided to both patients and medical providers.

Throughout the intervention phase, participants in the GAITSMART (intervention) group, who formed part of the study cohort, received four assessments at three-week intervals. The intervention took place in a peaceful, unobtrusive 10-meter hallway. Patients were instructed to wear supportive shoes, either flat or low-heeled, and to try to wear the same kind of shoes for every visit [12]. All the interventions were provided by the research team, who received their training from Dynamic Metrics Ltd. (DML). Typical physiotherapy services included a group of individuals who got guidance on self-rehabilitation, and standard care included regular advice on preventing falls. Those who were determined to be at danger of falling were included in this category. These individuals may be receiving assistance to reduce their risk of falling and to manage fall-related issues, such as pain, injuries, anxiety, loss of confidence, and diminished independence [13]. Additionally, as advised by NICE Clinical Guidance (CG 161), they may be receiving treatments that address many areas.

2.5 Time Horizon

As the benefits of the intervention typically emerge in the short term, a 12-month cost-effectiveness analysis (CEA) was conducted to assess the additional costs and advantages associated with the GAITSMART system. [14]. As the analysis only spanned a 12-month period, the discount rate for both expenses and advantages, as recommended in the NICE reference case, was not applied.

2.6 Outcomes

The GAITSMART system's impact was mainly looked at in terms of improving walking patterns, specifically by changing walking speed and lowering fear of falling. According to Zhu et al., both of these factors were used to see how fall risk changed and how that affected actual falls. When comparing the GAITSMART system to the standard care, the focus was on clinical results, health impacts, and costs [14].

Clinical outcomes were considered either mild or severe injuries caused by falls or multiple falls during the time period covered by the model. For the cost-effectiveness analysis, the key indicator adopted was the incremental cost-effectiveness ratio (ICER), which was based on improvements in walking speed and reductions in fear of falling.

2.7 Model Structure

A tree-based decision model was constructed within Microsoft Excel to evaluate and contrast the expenses and advantages of the current standard of care (SoC) approach with the novel care pathway that incorporates the GAITSMART intervention. Figure 1 depicts the way a cohort of patients who have sustained falls or have moderate to severe fear of falling may advance through this hypothetical decision framework over a 12-month timeframe, as depicted in Figure 1 below.

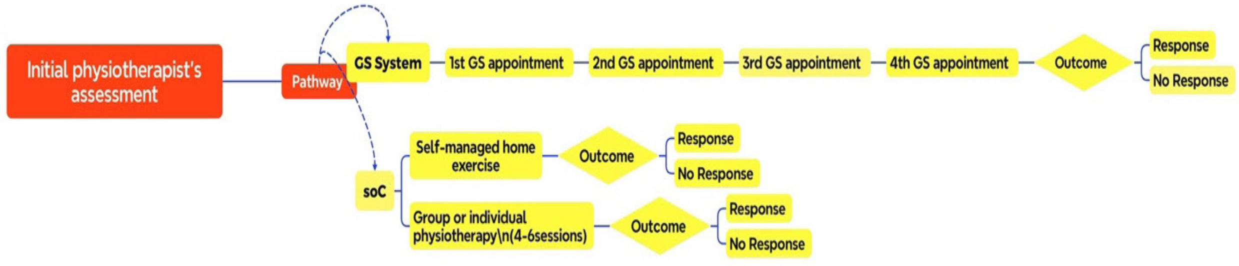

Fig. 1 Decision tree model of the GaitSmart system

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3 Model Inputs Parameters

3.1 Clinical Effectiveness

Data were collected from 86 community-dwelling frail older adults (mean age 80 years) at the Northeast London Foundation Trust (NELFT) as part of the European Technologies of Business Holding GaitSmart initiative. All participants had a history of falls and were receiving care at the Community Hospital [14]. Collected variables included age, walking aid use, fall history, Fear of Falling (FoF) scores, Functional Reach Test (FES-I) results, and intervention-related costs. Gait parameters were assessed on four occasions throughout the intervention period. At baseline and post-intervention, walking speed (in m/s), a composite gait score generated from GAITSMART outputs, and FES-I scores were recorded for all participants. Written informed consent was obtained from each subject prior to enrolment. This was an NHS-led service improvement project that did not require ethical approval.

The relative Risk of Falling (Risk of falling) on the subjects was obtained in literature both the correlation between the acceleration of gait speed by 0.1 meters per second and the decrease in the relative risk. This helped in formulating a personal risk of falling of each individual participant at the start of the project and the general assessment of the degree to which their risk of falling decreased depending on the increased speed they had.

The literature provided details regarding FoF of an individual, categorizing it into three levels: no fear of falling, moderate fear of falling, and severe fear of falling. Peer-reviewed publications also established the association between Fear of Falling and the incidence of falls and injuries sustained over the subsequent 12 months.

3.2 Costs

The NHS did the first economic review called EEE, using the Unit Costs of Health and Social Care 2018 and the yearly resource information from the Personal Social Services Research Unit. This review only looked at the direct medical costs, such as those for treatment and hospital visits, and did not include other costs like lost work time or help from family members [14]. To make the model work, they used data and information from studies and other research. This helped them find out the cost of falls and predict how the number of falls and fear of falling might go down in the group they chose. In 2018, all the costs for health services were measured in pounds. These costs included visits to a general practitioner, emergency hospital care, inpatient treatment, ambulance calls, and how long someone was in the hospital.

3.3 Utility Values

The values used to measure how useful the GAITSMART and SoC interventions were for people who responded and those who did not were taken from studies. These values were based on how many falls were expected at different levels of risk, right at the beginning and the end of the intervention.

3.4 Modeling Assumptions

A one-year timeframe was adopted for this study. Given that a randomized controlled clinical trial with a comparator group was not utilized, and the observation period for the study cohort was relatively short, the analysis relied on existing data regarding fall risk across different levels of fear of falling. It was followed by the distinction of a proxy comparison of the original falling risk through the use of the study. The statistics on the extent to which individuals have a high regard of various health outcomes were obtained through published research. The closest similar values which fitted the group was well chosen.

3.5 Sensitivity Analysis

To explore how uncertainties in the model's core parameters impact the incremental cost-effectiveness ratio (ICER) value, 1000 probabilistic sensitivity analyses were performed via Monte Carlo simulation. In each iteration, the key parameters were adjusted in accordance with their respective probability distributions. Based on these findings, a scatter plot comparing the ICER of the GAITSMART intervention against SoC and cost-effectiveness acceptability curves (CEACs) were generated. A univariate deterministic threshold analysis was additionally implemented to determine the cost threshold beyond which the GAITSMART system would no longer be considered cost-saving.

3.6 Return on Investment

The Return on Investment, or Return on investment, is used to evaluate how well an investment is performing. It shows up to what point the money invested in a particular health technology result in risk of falling or loss. This helps in understanding how effective the resources invested are. RETURN ON INVESTMENT was defined as avoided NHS costs minus intervention costs divided by intervention costs. made from the investment by the total cost of the investment. Since the result is a percentage, you need to multiply the ratio by 100, as shown in the formula

ROI = (Treatment Costs Saved) / (program Investment)

Where, treatment costs saved is given by cost of falls (CP) plus Physio Costs (CP)-costs of falls (IP) plus physio costs (IP).

It is noted that CP = Conventional pathway, IP=Interven-

tion pathway
This means that program Investment= Intervention Cost

4 Results

4.1 GaitSmart System Effectiveness

Fall risk estimates were generated individually, based on the degree of improvement in each participant's walking speed. This revealed a 1.77% average reduction in fall risk (baseline risk = 0.5, post-intervention risk = 0.482). In the NELFT cohort, 69 out of 86 patients demonstrated improvements in gait speed following four GAITSMART sessions. The largest observed increase in gait speed was more than threefold, leading to a 9.77% reduction in fall risk. Conversely, the smallest improvement in gait speed (2%) resulted in a 0.13% reduction in fall risk. Among non-responders—who may have had lower adherence or more severe baseline impairments that prevented improvement—fall risk actually increased by up to 2.3%.
When it comes to changes in Fear of falling, 45 percent of the participants had a lower level of Fear of falling after the intervention (in the GAITSMART group).
Additionally, A total of n = X participants moved from high to low Fear of falling categories based on predefined thresholds.
from a high level of Fear of falling to a low level.

4.2 Base Case

The outcome of the CEA after a year indicated that the patients under the GAITSMART intervention recorded better quality of life improvements [11]. The measurement of this was in terms of incremental quality adjusted life years (QALYs) where the values of 0.77 were created on fear of falling (Fear of falling) and values of 1.07 on actual falls (Risk of falling). Comparatively, the patients that had the standard-of-care (soC) intervention did not demonstrate such improvement. Also, GAITSMART system was determined to be less costly in the results investigated and the intervention paid off with an average of a cost saving of -X per patient in Fear of falling and -2901.79 in Risk of falling. Due to these advantages and saving GaitSmart, GAITSMART system is deemed to be the most appropriate compared to the SoC in assisting older adults who fell or are at the risk of falling thus improving the quality of life and reducing costs.

4.3 Sensitivity Analysis

Given the uncertainty in the model's input parameters, a probabilistic sensitivity analysis (PSA) was performed. Figure 2 presents a scatter plot of incremental cost-effectiveness (ICE), which helps evaluate the reliability and stability of the study's conclusions [11]. All simulated scenarios fall within the lower-right quadrant of the plot, clearly illustrating that the GAITSMART system yields greater clinical benefits while incurring lower costs compared to standard of care (SoC). Verifying that the GAITSMART system represents the optimal choice for improving mobility in older adults who have experienced a fall or who report moderate to severe fear of falling. According to the PSA results, the chance that the intervention is cost-effective is 79.4% for those who are afraid of falling (Fear of falling) and 100% for those who have already fallen (Risk of falling).

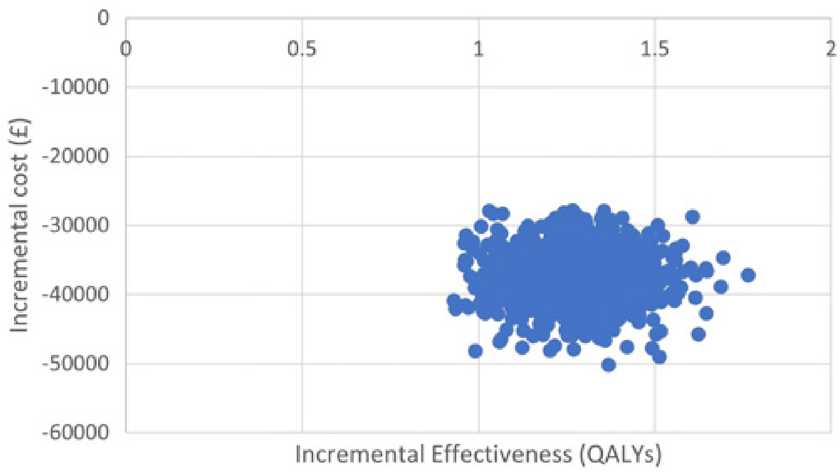

Fig. 2 The incremental cost effectiveness ratio of the GAITSMART system standard of care.

4.4 Qualys, Quality Adjusted Life-Years.

Quality Adjusted Life Years (QALYs) were adopted as the primary outcome metric. Across all simulated scenarios, the GAITSMART intervention was consistently identified as a cost-effective solution, regardless of the threshold value assigned to willingness-to-pay.

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4.5 Return on Investment

The curves in all cases support the results shown in the scatter plot. At this stage, the GAITSMART was looked at, and a RETURN ON INVESTMENT was calculated. The net RETURN ON INVESTMENT shows that using the GAITSMART system saves 1.85 pounds per patient compared to the SoC and saves 11.16 pounds per patient when compared to the Fear of falling reduction evaluation [14]. A RETURN ON INVESTMENT below one means the program costs more than the saving GaitSmart it brings GaitSmart. A RETURN ON INVESTMENT above one means the program saves more than it costs to run. Therefore, the GAITSMART system offers a good RETURN ON INVESTMENT and helps traditional physiotherapy by making it more efficient [11]. If conventional physiotherapy had been used, the RETURN ON INVESTMENT of the GAITSMART system would be even higher.

5 Discussion

In the NHS setting, the available resources should be apportioned by decision-makers to competing interventions. The cost-effectiveness analysis (CEA) assists in comparing the cost and benefits of various healthcare treatments, thereby assisting in making better decisions and more informed policies. The 12-month decision tree model was developed in attempts to evaluate potential outcomes of the implementation of the GAITSMART system versus the conventional care approach. The GAITSMART system could be the most effective in the prevention of falls and fear of falling among the elderly, according to the parameters of the study. It may be an economical intervention in the NHS, alone or as a combination with other interventions, including medicines, dietary assistance, mental health therapy, environmental or assistive device adaptations and educational initiatives [12]. The GAITSMART system was identified to enhance walking speed and fear of falling by an improvement of 1.77 % (95% CI = 1.05 % to 2.67 %) in the walking speed and 45% (95 % CI = 41.93% to 48.09 %) in the fear of falling when compared to usual care. Earlier research has looked at how fast people walk at different ages, and it found that when walking speed changes from the usual pattern, it may signal a problem [13]. Most of these studies indicate that a 0.05 m/s change in gait speed is a significant predictor of fall risk and overall well-being for older adults, and for those with walking difficulties, an improvement of more than 0.1 m/s is important.

Direct hospital expenditures represent only part of the overall economic burden associated with falls [4]. Also, fear of falling can make someone more likely to fall again in the future, which means more resources are needed from various groups like families and caregivers, the NHS, and local government. There are several ways to prevent falls, and the ones that focus on improving balance and daily living skills tend to work best.

The main strength of the study is that the most appropriate factors, such as increased walking speed and decreased fear of falling, were used to estimate the effectiveness of the GAITSMART system in the prevention of the risk of falling, as well as the value it possesses in terms of cost-effectiveness and investment returns. It is the first study in the UK and internationally to construct a novel health economic framework to evaluate the cost-effectiveness of the GAITSMART intervention in mitigating fall risk and to quantify the return on investment (ROI) for the NHS [5]. The evaluation objectives where Clinical improvements have been converted into an economic value in terms of decreased fall rates and reduced hospitalization. To accomplish this, exploratory economic model was prepared that was thorough enough to determine the economic effects in a place where both physical and mental aspects influence the confidence of a person in walking [6]. Consequently, it is feasible to model the cost and benefits of the prevention of falls risks on the basis of gait and fear of falling measurements. Although there is confusion as to the way fear of falling can be quantified, the experience demonstrates that the combination of powerful quantitative and qualitative indicators has enabled this to be affected.

The initial data from the GAITSMART system study shows that the intervention might be a good value for money compared to the usual care [7]. With falls costing the NHS over £4.4 billion each year, the GAITSMART system could make a big difference in making healthcare more efficient [6]. Early feedback suggests that the GAITSMART system is well-received by both patients and healthcare risk of falling sessional. The wearable is simple to operate as the patient has to wear the device by attaching the sensor components with straps to certain parts of their bodies. The device is not invasive and may be put on over the clothes, which makes it more acceptable and comfortable. The clinician feedback was favorable towards the perceived feasibility and usability of how the system may provide accurate information on walking patterns that would be used to plan better treatments Structured training sessions and continuous technical assistance were also included in the plan of implementation to the healthcare workers and also there will be assistance in case of any technical or practical problems. The GAITSMART system should be made better by receiving continuous feedback on it, both from the patients and the staff, as the latter continues to evolve.

There is a critical issue with simulation modeling that is applied to complex domains such as health and healthcare. They rely on a lot of assumptions on significant factors that are not completely known. Even though the main data used in the analysis is strong, there is not much information on how well each treatment works overtime. Because of this, the study looked only at a one-year period, assuming that all the benefits from the treatments would stop by the end of that time. However, this is not always true. Also, the results cannot be applied to everyone because the people in the study have certain traits that may not match those in real-world situations. So, the finding GaitSmart are only useful if the treatment is given to groups that are similar to the ones studied.

The finding GaitSmart are applicable to groups that are similar to those in the study. But it is likely that regional variation may influence staff time and service delivery intensity, which could affect the analysis results [8]. Particularly, the place will determine the extent to which it will be costly to implement the intervention. As an example, exercise sessions may be more expensive in the countryside due to the possibility that the personnel will have to travel further. Additionally, costs related to falls may vary depending on Integrated Care Board.

Moreover, the expenses and outcomes of long-term falls had not been considered since the research had not followed the participants over an extended duration, thus, it was not possible to make any assumptions regarding them. The cost-effectiveness of the screening and intervention could have a better look at it had those costs been considered. The model also fails to take into consideration socially care costs, when considering issues on a broader societal perspective and fails to quantify how an intervention impacts on the quality of life of a person. It is an indication that every intervention would be more successful. Nonetheless, the investment return would be varied in case the GAITSMART system was applied to a smaller group of risk [9]. Besides, Sex-stratified analysis could not be performed as the number of subgroups was not enough as the fall risks and effectiveness might be different across genders and could alter the results.

The research should involve randomized controlled trials over a long period to address the shortcoming GaitSmart and limitations of the initial study. This involves taking a closer look at the time on which this intervention occurred and what it was contrasted with which will render the data that is available more reliable and accurate.

6 Conclusion

According to the economic analysis, the GAITSMART system can be a more appropriate choice as compared to the SoC based on the current trends. It is more efficient and less expensive. Hence, as per the model, the GAITSMART system may be used with old individuals who have fallen and fear of falling, which would save money.

Although the GAITSMART intervention has demonstrated highly favorable cost-effectiveness outcomes, considerable caution is warranted given the study's limitations. Readers must recognize that the majority of monetary gains stem not from direct cost savings, but from the avoidance of expenditures—such as reduced hospital bed occupancy due to fewer inpatient admissions. These saving GaitSmart do not provide real money that can be used in other areas, but they assist in relieving the pressure on NHS. More research is needed to understand the uncertainties better and make the evidence stronger.

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