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A pilot study of an accelerometer-equipped smartphone to monitor older adults with cancer receiving chemotherapy in Mexico

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ABSTRACT

Objectives: Older adults with cancer in developing countries face challenges accessing healthcare due to a lack of personnel and infrastructure. A decline in physical activity (defined as a decrease in the number of daily steps) may be a novel method for the timely detection of toxicity in older adults receiving chemotherapy in resource-constrained settings.
Materials and Methods: In this feasibility study, patients aged ≥65 years starting first-line chemotherapy for solid tumors were given a smartphone with a pedometer application. Daily steps were monitored daily for one cycle. If a ≥15% decrease from baseline was identified, the patient was called and the presence of toxicity assessed. The intervention would be feasible if ≥75% of the subjects recorded steps for ≥75% of the planned chemotherapy days.
Results: Forty patients (median age 73; 57% [N = 23] female) were included. Seventy percent (N = 28) had stage III-IV disease with 45% (N = 18) gastrointestinal, 23% (N = 9) breast, and 32% (N = 13) other malignancies. Mean pre-treatment daily steps was 3111 (Standard Deviation [SD] 1731), and median follow-up was 21 days (range 2–28). Despite having limited exposure to mobile technology, most (93%) patients used the smartphone appropriately, and 85% found it easy to use. Sixty percent of patients (N = 24) had toxicities managed over the phone, 27.5% (N = 10) were sent for urgent medical attention and 15% (N = 6) were hospitalized.
Conclusion: Using smartphones to monitor older adults with cancer receiving chemotherapy in a resource-constrained setting is feasible and acceptable. A decrease in the number of daily steps was common and helped to identify chemotherapy toxicity.

1. Introduction

Older adults with cancer receiving chemotherapy are at a greater risk for toxicity, including serious adverse effects and death [1]. This vulnerability is a consequence of several factors that vary widely by patient, including comorbidities, physiological changes related to aging, cognitive issues, reduced physical function, and social isolation [2,3]. Older adults receiving chemotherapy are at a higher risk of hospitalization and of early treatment discontinuation due to adverse effects [4,5], and are less likely to be offered treatment [6].

A large proportion of chemotherapy related adverse events in older adults may be preventable through evidence-based patient management, prophylactic interventions, and effective outpatient care [5,7]. However, even in developed nations, healthcare systems are poorly prepared to provide such comprehensive follow-up to older adults with cancer, in part due to a shortage of trained healthcare providers [8]. In developing countries, the expected increase in the number of people entering old age in the coming years will greatly challenge national infrastructures, particularly health systems [9]. In Mexico, as in other low-and middle-income countries (LMIC), the scarcity of trained providers (including oncologists, geriatricians, and other healthcare personnel) makes it difficult to provide adequate follow-up care for all older patients with cancer [10,11]. Furthermore, patients have limited access to telephone triage mechanisms or systems to report treatment toxicities, and adverse events can go unnoticed for considerable amounts of time. Therefore, new solutions are needed to detect those patients in greater need for follow up in order to enhance the reach of the healthcare system and to optimize the existing resources.

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The utilization of mobile phones to remotely monitor patients may represent a solution to fix current gaps in the reach of healthcare systems in LMIC [12]. Eighty percent of the world's population lives in areas with mobile network coverage, and over 4.7 billion people worldwide have mobile phones [13]. Furthermore, the highest growth in the number of smartphones is occurring in the developing world, where 60–70% of the population is expected to own one by 2020 [13]. Modern smartphones are mobile hand-held computers with integrated communication and sensors, which offer endless possibilities for connectivity and for monitoring vital parameters and patient reported outcomes (PRO), which can be easily accessed and reviewed by healthcare providers in a relatively short amount of time.

Most existing studies on remote monitoring of patients with cancer have been carried out in developed countries using either PRO questionnaires or sophisticated monitoring systems or devices [14–18]. However, their results cannot be extrapolated to older adults living in developing regions of the world, many of which have limited health literacy and lack experience with the use of mobile technology [19]. On the other hand, smartphone sensors are able to provide data that are not dependent on a patient's cognition, literacy, language or health status, and can provide measures of physical performance which may represent a surrogate of functional status, well-being and symptoms [17]. In this pilot study, we hypothesized that a decline in physical activity, defined as a decrease in the number of daily steps, could represent a novel method for the timely detection of toxicity in older adults receiving chemotherapy in a resource-constrained country. Our objective was to determine the feasibility and acceptability of using smartphones to remotely monitor the daily steps of older adults with cancer receiving chemotherapy in Mexico, and to explore whether a predefined change in daily steps was associated with the presence of Grade 2–4 chemotherapy toxicity.

2. Materials and Methods

2.1. Participants and Settings

Inclusion criteria for the current study were: 1) age ≥ 65 years; 2) a diagnosis of any solid malignancy; and 3) starting first-line chemotherapy in the adjuvant, metastatic, or recurrent setting in seven or more days after signing consent. Patients who used walking aids were excluded because the accuracy of sensors and accelerometers is diminished under such circumstances [20]. Patients who self-rated their eyesight as “totally blind” and/or their hearing as “totally deaf” were also excluded, as well as those in which chemotherapy was planned to start in less than seven days from the time of recruitment. The study was conducted at the oncology clinics at *Instituto Nacional de Ciencias Medicas y Nutricion Salvador Zubiran* (INCMNSZ) in Mexico City. Institutional review board approval was obtained at INCMNSZ, the patient's treating oncologists were notified, and written informed consent was obtained from all participants.

2.2. Interventions

Consecutive patients seen at the various oncology clinics at INCMNSZ and who fulfilled the inclusion criteria were approached by research staff and completed informed consent. Baseline sociodemographic data, tumor and treatment characteristics, and information about previous use of mobile technology were collected. All patients underwent a baseline geriatric assessment that included measures of functional status (activities of daily living [ADL] [21], instrumental activities of daily living [IADL] [22], presence of falls); physical performance (Timed Up-and-Go test [TUG]) [23]; number of comorbidities; nutritional status (weight loss); social support (Older Americans Resources and Services questionnaire) [24]; number of prescribed medications; psychological status (Mental Health Inventory-17 questionnaire) [21] and cognition (Blessed Orientation-Memory-Concentration [BOMC] test) [25]. This set of measures has been validated in Spanish and has been utilized before to assess older adults with cancer undergoing chemotherapy [26,27].

After completing the baseline clinical assessments, patients were provided with a Global System for Mobile communications (GSM) accelerometer-equipped Android smartphone (Oppo R831, OPPO Electronics Corp, Dongguan, Guangdong, China) with an installed open source, freely available pedometer application (Google Fit, Google, CA, United States) [28] which records the number of steps taken in real time. Modern smartphone accelerometer-based applications have been found to be reliable to assess the number of steps taken per day when compared with traditional pedometers [29,30]. De-identified data obtained from this application is automatically uploaded to a password-protected, cloud-based server that can be remotely monitored through a web-based platform. Global positioning system (GPS) and other tracking features of the device were deactivated to ensure participant privacy. All participants and their caregivers underwent an educational session in which a member of the research team explained how to properly charge, answer, and carry the smartphone. Patients were instructed to carry the phone around their hips during waking hours, regardless of whether they were at home or outside (a nylon hip holster was provided) and to keep it turned on at all times.

Daily steps were recorded for at least seven days before the start of chemotherapy, and a mean baseline number of steps was calculated for each patient by dividing the sum of all the steps taken by the number of pre-chemotherapy follow-up days. On the day of the first chemotherapy dose patients received side effect education as per standard of care and education regarding the proper use of the smartphone. The patients were instructed to continue carrying the smartphone as indicated for the entire duration of the first chemotherapy cycle. The number of steps per day was monitored daily by a general practitioner (MPRC) by logging onto a secure online account and compared with mean number of baseline steps per day. On those days in which a ≥15% decline from mean baseline steps per day was observed (≤85% of mean baseline number of steps per day), the patient was contacted on the study provided smartphone by the general practitioner, who assessed for symptoms and chemotherapy related toxicity by directly asking the patient. Patients who failed to record steps were also called. Interventions ranging from providing advice and education, prescribing over-the-counter medications, or prompting the patient to go to the clinic or to the nearest emergency department for evaluation were instituted with support from an oncologist (ESPC) if any significant chemotherapy toxicities (defined as any Grade 2 to 4 toxicity according to the Common Terminology Criteria for Adverse Events [CTCAE] 4.0) were identified [31]. Although Grade 1 toxicities may be significant in older adults, these were not recorded by the general practitioner in order to make the calls as short as possible and reduce patient burden.

At the end of the first chemotherapy cycle (or sooner if the patient was hospitalized overnight), the subjects rated the ease of use of the smartphone using a 10-centimeter visual analog scale (VAS) and open-ended questions. Fig. 1 shows a graphical description of the study design.

2.3. Objectives, Outcomes, Feasibility Criteria, and Statistical Methods

The primary objective of the study was to determine the feasibility and acceptability of monitoring the number of daily steps of older adults with cancer receiving chemotherapy using a smartphone. The intervention would be considered feasible if ≥75% of the subjects recorded steps for ≥75% of the days of the total planned chemotherapy cycle. Steps were considered to be recorded if at least one step was uploaded to the cloud-based server by the following morning. Previous studies have excluded daily step counts below the fifth percentile of normative values, but due to the lack of information for the Mexican population we decided to count any uploaded activity as a recording [32]. The proportion of days with recorded steps was calculated by dividing the number of days with recorded steps over the total number of follow-up days.

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