

## Original article

## A Systematic Review of Economic Evaluations of Pacemaker Telemonitoring Systems

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## ABSTRACT

**Introduction and objectives:** Over the last decade, telemedicine applied to pacemaker monitoring has undergone extraordinary growth. It is not known if telemoitoring is more or less efficient than conventional monitoring. The aim of this study was to carry out a systematic review analyzing the available evidence on resource use and health outcomes in both follow-up modalities.

**Methods:** We searched 11 databases and included studies published up until November 2014. The inclusion criteria were: *a*) experimental or observational design; *b*) studies based on complete economic evaluations; *c*) patients with pacemakers, and *d*) telemoitoring compared with conventional hospital monitoring.

**Results:** Seven studies met the inclusion criteria, providing information on 2852 patients, with a mean age of 81 years. The main indication for device implantation was atrioventricular block. With telemoitoring, cardiovascular events were detected and treated 2 months earlier than with conventional monitoring, thus reducing length of hospital stay by 34% and reducing routine and emergency hospital visits as well. There were no significant intergroup differences in perceived quality of life or number of adverse events. The cost of telemoitoring was 60% lower than that of conventional hospital monitoring.

**Conclusions:** Compared with conventional monitoring, cardiovascular events were detected earlier and the number of hospitalizations and hospital visits was reduced with pacemaker telemoitoring. In addition, the costs associated with follow-up were lower with telemoitoring.

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## Revisión sistemática de evaluaciones económicas de los sistemas de telemoitorización en los marcapasos

## RESUMEN

**Introducción y objetivos:** En la última década, la telemedicina aplicada a la monitorización de marcapasos cardíacos ha experimentado un extraordinario crecimiento. Se desconoce si esta tecnología tiene una eficiencia diferente de la convencional. El objetivo del estudio es realizar una revisión sistemática analizando la evidencia disponible con respecto al consumo de recursos y los resultados en salud en ambas modalidades de seguimiento.

**Métodos:** La búsqueda se realizó en 11 bases de datos y se incluyeron estudios publicados hasta noviembre de 2014. Los criterios de inclusión fueron: *a*) diseño experimental u observacional; *b*) estudios basados en evaluaciones económicas completas; *c*) pacientes con marcapasos, y *d*) telemoitorización comparada con la modalidad hospitalaria.

**Resultados:** Siete estudios cumplían los criterios de inclusión, con información sobre 2.852 pacientes con una media de edad de 81 años; el bloqueo auriculoventricular era la principal indicación. En la telemoitorización, los eventos cardiovasculares se detectan y tratan 2 meses antes, con lo que se reduce en un 34% el número de hospitalizaciones, así como las visitas rutinarias y de urgencias al hospital. No hubo diferencias intergrupales significativas en calidad de vida percibida o número de eventos adversos. El coste de la telemoitorización es un 60% menor que el de la monitorización hospitalaria.

## Palabras clave:

Estudios de seguimiento

Gasto cardíaco

Marcapasos

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**Conclusiones:** En la telemonitorización de marcapasos, los eventos cardiovasculares se detectan antes y disminuyen las hospitalizaciones y el número de visitas al hospital. Además, con la telemonitorización se reducen los costes asociados al seguimiento.

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## Abbreviations

HM: hospital monitoring  
TM: telemonitoring

## INTRODUCTION

Cardiovascular disease is one of the leading causes of morbidity and mortality and is responsible for 30% of worldwide mortality, according to the World Health Organization.<sup>1</sup> The incidence of cardiovascular disease has been affected by the increase in life expectancy and consequent aging population, and some of these patients require cardiovascular implantable electronic devices. The number of cardiovascular implantable electronic devices—which includes pacemakers, implantable cardioverter-defibrillators, cardiac resynchronization therapy, and Holters—has increased at an exponential rate since the first implant<sup>2</sup> in 1958, and continues to do so. A pacemaker is an electronic device designed to produce electrical impulses to stimulate the heart when normal physiological stimulation fails.<sup>3</sup> The increase in the number of pacemakers implanted in the last decade, amongst other reasons, has led to the saturation of cardiology clinics.<sup>4,5</sup>

Telemonitoring (TM) consists of using electronic equipment to observe and record physiological processes while patients carry out their activities of daily living. This means the remote measurement of physiological processes such as vital signs (for example heart rate, respiratory rate, and blood pressure) and other measurements (such as blood counts, blood biochemistry, and renal production) with digital and analogue technology.<sup>6</sup> This technology originated in the 1970s, when transtelephonic monitoring was introduced,<sup>7</sup> and the first pacemaker that could be remotely monitored using telephone lines, cable networks, and/or broadband was introduced at the beginning of the 21<sup>st</sup> century.<sup>8</sup> Transtelephonic monitoring was able to supply basic information, such as warning of imminent battery depletion, but it did not report problems with device functioning or the control of incorrectly programmed parameters. The introduction of telemonitoring has allowed access to a large amount of information, with the advantage that health professionals can consult it at any time. The development and expansion of pacemaker TM means that studies are required to show its efficiency compared with hospital monitoring (HM). Therefore, the aim of this study was to conduct a systematic review of economic evaluations to analyze the evidence available on resource use and health outcomes for both follow-up modalities.

## METHODS

### Search Strategy

The literature search was conducted on 1 December 2014, with no restrictions on language or year of publication. The databases used were MEDLINE (via PubMed), EMBASE, DARE, HTA, NHS

Economic Evaluation Database (NHS EED), LILACS, IMA, CUIDEN, and the doctoral theses available on Teseo, TDR, and Dialnet. We also searched the gray literature: acts of congress, books, and academic publications; and we hand-searched bibliographic references that were considered to be of interest and that were included in systematic reviews and meta-analyses. The Boolean operators used were AND and OR. The following English search terms were used: pacemaker, telemedicine, remote consultation, home monitoring, and cost-benefit analysis. The following Spanish descriptors/key words were used: *marcapasos*, *telemedicina*, *consulta remota*, *monitorización domiciliaria*, and *análisis de coste-beneficio*. The key words or terms search was performed on all the selected databases in the review and on the complete article, including the title, summary, text, and key words. The inclusion criteria for studies were: *a*) experimental or observational design; *b*) studies based on complete economic evaluations, that is, studies comparing health outcomes and costs, with no exclusions for analysis method (cost-effectiveness, cost-utility, cost-benefit, and cost-minimization); *c*) patients with pacemakers, and *d*) TM compared with HM.

### Data Extraction

In December 2014, using the search strategy, 2 investigators (Antonio López-Villegas and Irene Villegas-Tripiana) independently extracted the data and read the titles and summaries of all the initially selected studies (Table 1). As stated in the study aims, articles that could potentially meet the inclusion criteria were preselected. The following month, the same 2 investigators read the full texts of the previously screened articles. When there was no consensus on the inclusion or exclusion of an article, a third investigator (Daniel Catalán-Matamoros) mediated. The variables included in the data analysis were: *a*) study characteristics (author, year of publication, country, study duration, sample size, age, sex, main indication for implantation, and pacemaker used), and *b*) analysis and main results of the variables (analysis performed, primary endpoints, secondary endpoints, health outcomes and cost outcomes). Two revisers (Carlos Martín-Saborido and Emilio Robles-Musso) independently evaluated the methodological quality of the selected articles using the checklist of López-Bastida et al<sup>9</sup> as an assessment tool.

**Table 1**  
Search Strategy Used in MEDLINE (via PubMed)

	Search terms
#1	Search (pacemaker) OR pacemakers
#2	Search telemedicine
#3	Search remote consultation
#4	Search home monitoring
#5	Search (((cost-benefit analysis) OR cost benefit analysis) OR cost benefit) OR cost-benefit
#6	#1 and #2 or #3 or #4
#7	#1 and #5
#8	#6 and #7

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