

# PAOLINA (PAziente on LIne, Ambulatoriale) as a Web Application for Facilitating the Storage and the Management of Self-Measured Blood Pressure Data

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## Abstract

*Introduction.* Self-measurement of blood pressure at home (a.k.a. home blood pressure = HBP) is accepted by the international medical guidelines as an effective procedure for the management of arterial hypertension and is increasingly popular among hypertensive patients. This, however, transfers on the patients' side the responsibility of data acquisition, storage and management. PAOLINA represents a Web application that allows the patients at home, to input, store and consult their own home pressure measurements. At the same time, it permits the consultation of the data by authorized health providers. The system favours a more correct use of acquired information and provides guidelines for the proper method of long-term HBP monitoring. The system is a pilot study with the aim of achieving greater and more proper involvement of the patient at the same time making easier and more efficient his interaction with the health facility, by moving whenever possible, the information rather than the patient.

*Methods.* PAOLINA is a php5 web application based upon Zend Framework. We make use of the industry standard web application design pattern MVC, which allows our developers and web designers to separate their concerns and skills, making code implementation and design easily and clearly separated. We have built our application model using standard database programming best practices and mySQL database engine. PAOLINA is I18N and L10N ready allowing its future use around the world.

*Results and Discussion.* PAOLINA is hosted on an Apple's minimac dressing an 2 GHz Intel Core Duo with 2 GB 667 Mhz DDR2 SDRAM running Apache 2.2.6 Web server. The current features set includes, among other, methods for authentication and authorization of PAOLINA's users, validation and registration of HBP, presentation of acquired data in tabular and graphical format. Several users at present benefit from using PAOLINA and are providing us with helpful feedback for a better and more feature-rich application.

*The application of this approach for other easily collectible clinically relevant information is envisaged.*

## 1. Introduction

The following premises are at the base of the present project:

despite extensive effort, hypertension control at the population level is still unsatisfactory and this is in part also due to the patient's lack of compliance with prescribed drug treatment, and the lack of adherence to lifestyle changes [1];

a growing advocacy exists for a more "patient-centered" (as opposed to a paternalistic "doctor-centered") approach to health care [2,3];

a number of satisfactorily functioning devices for self-measurement of blood pressure have been developed and validated in a series of studies [1];

in the management of arterial hypertension, self-measured blood pressure (a.k.a. "home blood pressure") has been demonstrated to be superior to office blood pressure [4-9] and at least equally effective as (but less expensive than) ambulatory blood pressure [7,8].

Taking these premises into account, it is tempting to speculate that a more patient-centered approach to the management of hypertension that, to a substantial extent, relies on self-measured blood pressure may represent a "rewarding system" that may encourage compliance with treatment and adherence to lifestyle changes [10-17]. For properly functioning, such a system would however also have the following requirements:

to facilitate patient education; i.e. to facilitate the correctness of the measurement procedures and (at least of equal importance) of the management of the information derived from these measurements, taking into account the recent statements of *ad hoc* bodies of the

American and European Hypertension Societies [18,19];

to permit connection (without misusing it) to more knowledgeable health providers (chosen by the patient).

## 2. Methods

The considerations reported above have led us to develop a web-based application that provides:

- 1.) proper information on a.) instrumentation (what to use); b.) measurement procedure (when and how to measure blood pressure; what to avoid before and during measuring); c.) management of multiple readings (how many readings at one occasion, how many times and at what interval to repeat them);
- 2.) a user-friendly interface for data input and a quality control of data;
- 3.) a user-friendly interface for output data (list of individual measurements, averages and time course);
- 4.) a help for “understanding” the content of the data in order to avoid overinterpretation, unnecessary stress and induction of inappropriate seeking of medical advice. In particular, the following points are taken into account: a.) emphasis on *average*, rather than individual readings; b.) recognition of the natural fluctuation of blood pressure; c.) knowledge of targets to be achieved; d.) information on when a contact with the doctor is advisable;
- 5.) a means for storing blood pressure measurements over time for future retrieval and comparison;
- 6.) the possibility of access to the data by the doctor (authorized by the patient).

To achieve the above goal we have chosen to use the MVC (Model View Control) pattern for PAOLINA development. In other words, we have broken down our application into a series of layers, where each layer is a discrete, orthogonal area of concern within the application.

The user interface layer is responsible for presenting the application to the end user and is made using the infrastructure provided by Zend Framework [20]. We have also used the framework to interface the persistence layer provided by MySQL relational database. Finally the “C” part of MVC pattern is implemented through a series

of “action” controllers based on template provided by the same framework. The glue of the entire system is given by the domain model coded in strict object version of php.



Figure 1. PAOLINA Model View Control.

Isolating problem domains into separate layers creates a flexible and testable application allowing our developers and web designers to separate their concerns and skills, making code implementation and design easily and clearly separated.

## 3. Results

A beta version (in Italian) has been released and is currently being tested by a limited number of users providing us with useful feedback.



Figure 2. PAOLINA's Homepage.

The system is built upon a standard set of (X)HTML pages generated automatically using the Zend's

framework view templating engine [20]. A few example pages are reported below.

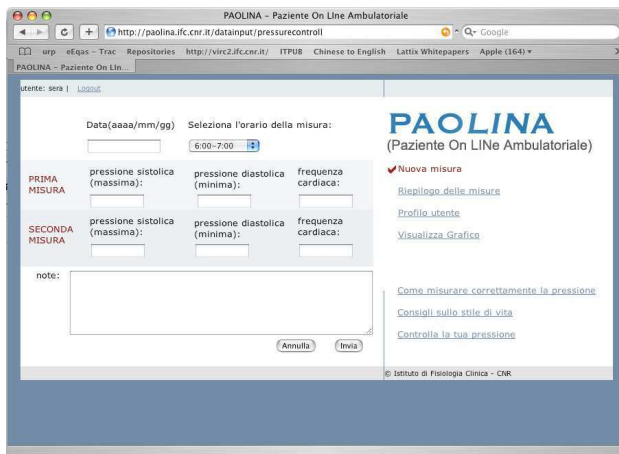


Figure 3. Data input page (new measurement).

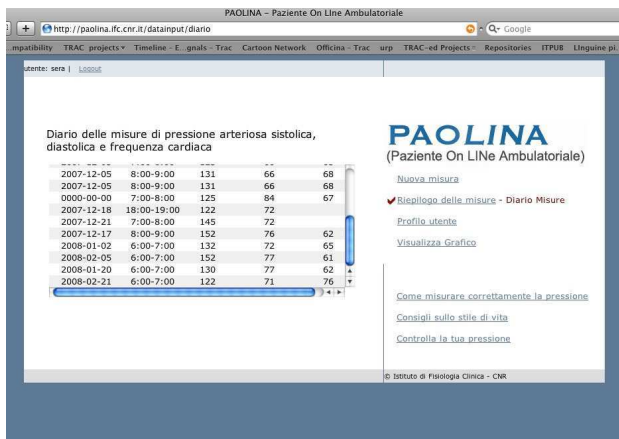


Figure 4. Data output page (tabular form).

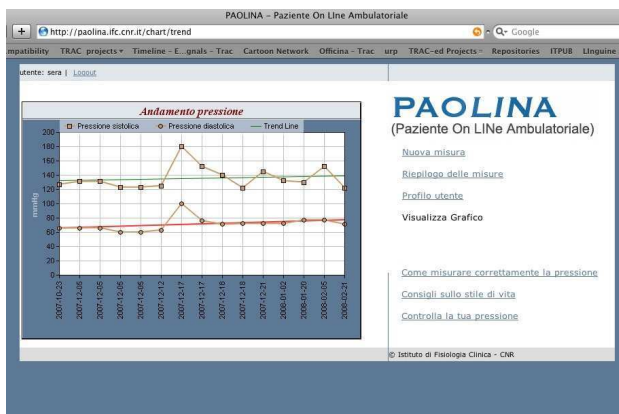


Figure 5. Data output page (graphical form: time course).

## 4. Discussion and conclusions

Home blood pressure monitoring overcomes many of the limitations of traditional office blood pressure measurement and is both easier and cheaper than ambulatory blood pressure monitoring [18], but poses new problems since it transfers on the patient's side the task of proper management, in terms of data acquisition, data storing and actions to be done. Web-based applications such as the one described here and others recently reported [21,22] may represent useful tools to assist patients with self-management of their hypertension. Studies will be needed to optimize these tools and to assess their efficacy in terms of blood pressure control, cost-effectiveness and customer satisfaction.

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