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Family Health Units vs. Primary Health Care Centres

Development of discrete event simulation models to compare the performance of the two organizational models

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Abstract

There has been an increasing need for a more efficient organization of primary health care sectors within National Health Service (NHS) based countries. Several governments have attempted to stimulate efficiency improvements by means of innovative reforms in the organization of primary care units. Within this movement, the Portuguese government has recently started a set of reforms that aimed at changing the organizational structure of the primary care sector by introducing a new type of organization structure based on Family Health Units (FHU). Few studies in literature have quantified the impact of these recent primary care reforms. The creation of models and tools for appraisal of future health care reforms and for evaluation of past reforms is highly valuable both to health care policy makers and to planners. This thesis proposes a tool to compare differences in performance between two primary care organizational models and to evaluate the impact of extending current reforms in the Portuguese primary care sector. Namely, stochastic discrete event simulation models were built with the purpose of comparing the performance of the recently implemented family health units (FHUs) vs. primary health care centres (PHCCs). Simulation models allow for a comparison of the two organization model on a set of key performance indicators, which include: queuing times for patients to be taken care of, percentage of use of human resources, number of consultations per professional, and costs (namely costs with personnel and costs with diagnostic tests and other treatments).

The simulation models were implemented in the Simul8 simulation software and embraced nineteen primary health care units from three municipalities of the Greater Lisbon sub-region: *Lisbon*, *Oeiras* and *Cascais*. Using the available information regarding the resources, production and costs of these units, the correspondent models were calibrated and validated.

After the validation of the models, we compared the two organizational models and analysed with detail the effect of a direct conversion of all studied PHCCs into FHUs. This scenario aimed at estimating which possible gains or losses might result from the complete conversion of PHCCs into FHU. Key results follow: a potential increase of 10% in the 'production' of ambulatory consultations that might contribute for solving the problem of having population not allocated to a GP; there is an average reduction in the number of days for a consultation in 50%, meaning that substantial gains on scheduling appointments and consequently gains in access of populations to care are achieved; regarding acute cases, there is a potential decrease on waiting times from the shifting of large PHCCs, and thus improving efficiency and quality in health care delivery; and finally, regarding the costs, results suggest an increase on overall costs for smaller PHCCs and the opposite (cost reductions) for the conversion of large PHCCs into FHUs.

From all the obtained results, the final conclusion for the present study is that the ongoing Portuguese primary health care reform of implementing family health units leads to visible improvements on the accessibility, efficiency, quality and costs within this sector.

Keywords: Family health units, primary health care, simulation, DES, performance indicators

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List of abbreviations

ARSLVT – Regional Health Administration of Lisbon and Tagus Valley
ASRV – Assistance Shared Resources' Unit
CA – Contracting Agency
CI – Confidence Intervals
CHH - Community Health Units
ERR – Experimental Remuneration Regime
FHU – Family Health Units
GP – General Practitioner
KPI – Key Performance Indicators
MoH – Ministry of Health
NHS – National Health Service
PHC – Primary Health Care
PHCC – Primary Health Care Centre
PHCG – Primary Health Care Group
PHCM – Primary Health Care Mission
PHCU - Personalised Health Care Units
PHU - Public Health Units
RHA – Regional Health Administration

Introduction

During the last years, there has been a growing attempt to stimulate different ways of management and organization within the healthcare sector of several NHS countries. This need for a more efficient management should promote cost containment, despite maintaining the levels of quality and capacity of response. Within this movement, the Portuguese government has recently started a set of reforms that aimed at changing the organizational structure of the primary care sector by introducing a new type of organization structure based on Family Health Units (FHU). Few studies in literature have quantified the impact of recent primary care reforms. This way, the development of tools that contribute to the evaluation of the actual system and enable the testing of new scenarios constitutes a surplus value for the respective decision-making authorities.

The aim of the present work was to evaluate one of latest and more innovative reforms, recently implemented by the Portuguese government within the primary health care sector – the creation of family health units (FHUs). A tool is proposed with the goal of comparing the differences in performance between the two existing types of primary care units (primary health care centres and family health units) and to evaluate the impact of extending the current reforms in the Portuguese primary care sector.

Regarding the goals of the present work, two discrete event simulation models were defined taking into account the correspondent organizational characteristics of primary health care centres and family health units. A set of key performance indicators (KPIs) were used in these models, allowing us to have a closer inside of the current situation in these units and comparing the differences between these organizational models. The indicators used can be grouped in four categories: queuing times, percentage of use of personnel, number of consultations per professional and costs.

The conceptual models proposed, were then implemented a specific discrete simulation software – the Simul8 software program (Simul8 Corporation 2000) applying them to a case study that included nineteen primary health care units – twelve primary health care centres and seven family health units – from three municipalities of the Greater Lisbon sub-region: *Lisbon*, *Oeiras* and *Cascais*. Using the available information regarding the resources, production and costs of these units, the correspondent models were calibrated and validated.

This thesis is structured in the following chapters:

- Chapter 2 introduces and briefly describes the evolution of the Portuguese health system and of the Portuguese National Health Service (NHS). This description emphasizes the concept and the importance of the primary health care sector, as well as summarises the evolution of the Portuguese primary health care sector, its key characteristics and ongoing reforms.

- Chapter 3 briefly reviews the importance of primary health care reforms in NHS and non-NHS based countries. A closer look is given to countries that have been undertaking reforms similar to the ones being implemented in Portugal. We focus on reforms being carried in Canada (a non-NHS based country); and on reforms being carried on the United Kingdom (UK), a NHS based country where several important primary health care reforms have been implemented during the last decades. We focus on two reforms implemented in the UK: the creation of Primary Care Groups (later named Primary Care Trusts) and the introduction of incentive-based contracts for general practitioners.

- Chapter 4 reviews available methods to quantify and analyse the impact of ongoing reforms in the Portuguese NHS. We explain why we have chosen to develop discrete event simulation models, and we propose to use two conceptual models to compare the two organizational models being used in the Portuguese primary care sector and to evaluate the impact extending the FHU organizational model to other primary health care units. Finally, after implementing the model in the Simul8 software and applying it to a case study of the Portuguese NHS, we calibrate and validate the models to ensure that the models accurately follow the behaviour of existing PHCCs and FHUs.

- In chapter 5 we first compare the results obtained for the simulation models of PHCCs and FHUs for 2007. A detailed analysis of these results is then carried in order to understand how organizational differences between primary health care centres and family health units lead to differences on the KPIs. Afterwards, we explore the scenario of converting all studied primary health care centres into family health units. This scenario aimed at capturing possible gains in efficiency, quality or costs that may arise from the complete application of the current primary health care reform of the Ministry of Health to the primary health care sector.

- Chapter 6 discusses results from applying the simulation models. Both the 2007 year and the new scenario results' are analysed in order to evaluate the possible gains that result from the FHU reform.

- Finally, in chapter 7 we present the main conclusions and discuss some for possible future developments of the work carried out in this thesis.

2. Context and case study

This chapter starts by briefly presenting the evolution of the Portuguese health system and of the Portuguese National Health Service (NHS). Afterwards we describe the role of the primary health care sector in a health system, its characteristics, and present some key features of the Portuguese primary care sector, including ongoing reforms.

2.1. The Portuguese health system and the National Health Service (NHS)

The organization of the Portuguese public health system was initiated in 1899 by Dr. Ricardo Jorge with the creation of the "*Serviços de Saúde e Beneficência Pública*". Until then, general health care was provided privately. In 1945, this service was expanded with the integration of maternity services and children health care. Despite these improvements, all the costs associated from health care delivery were still supported by the patient (Biscaia et al. 2005).

The first sketch of a Portuguese NHS appeared in 1971 with the "*Gonçalves Ferreira Reform*" that recognized the role of the Portuguese State in ensuring an equal right to access health care for all the Portuguese population. This reform led to the creation of the first generation of health care centers. They were responsible not only for the prevention of certain contagious diseases through vaccination campaigns but also for the assistance of more vulnerable groups like pregnant women and children. These centers coexisted with other institutions that provided health care coverage to workers and to their families - "*Serviços Médico-Sociais das Caixas de Previdência*" (Branco et al. 2001).

In 1978, with the "Arnault's dispatch", all Portuguese citizens were entitled to benefit from "*Previdência Social*", later named Social Security. This law and other changes in the Portuguese Constitution have contributed for the creation in 1979 of the Portuguese NHS whereas: "(health care should be) financed by the State" and "all Portuguese citizens, apart from their economic capacity, have the right to access to general and free health care" (Constituição Portuguesa 1976).

Six years later, in 1982, eighteen Regional Health Administrations (RHA) were created, as well as the general practitioner (GP) career was legislated (Ministério da Saúde 1982). In 1983, with the dispatch nº 97/83, the second generation of primary health care centres was defined as a result of the merge between the first generation primary health care centres – the "*Serviços Médico-Sociais das Caixas de Previdência*" – and municipal hospitals (Branco & Ramos 2001; Gouveia et al. 2007a).

In 1990, the NHS basis law ("*Lei de Bases da Saúde*") was approved not only re-stating that individual's access to health care is a right, but also that the State should be responsible for the promotion of the equal access to health care for all citizens. This law allowed for private management of public hospitals and defined the role for health insurance within the Portuguese

NHS. Three years later, the NHS statute was approved and redefined into five Regional Health Administrations (RHAs) responsible for the coordination of the work between hospitals and primary care centres in the mainland Portuguese territory (Biscaia et al. 2005).

Around 1996, these RHAs started a process that led to the constitution of the Contracting Agency. This institution should be responsible for the analysis, negotiation, supervision and distribution of financial resources within each geographic area (Agência de Contratualização dos Serviços de Saúde 2006).

This period, in the mid 90's, was characterized by a growing attempt to stimulate different ways of managing and organizing NHS units. The need for a more efficient management that would promote cost containment, gave rise to the adoption of enterprise management models and consequently to deep modifications on the NHS basis law ("*Lei de Bases da Saúde*"). From 2002, new partnerships between the public and private sector were established in order to build and manage new hospitals – Public-Private Partnerships (PPP). These new health care management models constituted a corporation type of organization.

In 2004 the government built the National Health Plan to be applied to 2004-2010 period (Direcção Geral de Saúde 2004). This document defined key strategic orientations for the health sector for that period, defining targets for some health indicators to be achieved in 2010. Moreover, it defined policies that aimed at promoting social justice, universality, equality, sustainability, solidarity and autonomy, clearly stating the need for strengthening the role of the primary care sector in health care promotion and prevention.

With the 2005 legislative elections, there was a changed from a government coalition joining the Social Democrat Party and the Popular Party to a Socialist government with a majority in the Portuguese parliament. The new government defined a new agenda for health care, setting as priorities: the Primary Health Care reform, the implementation of the National Network of Integrated Continued Health care, and the financial sustainability of the NHS (Ministério das Finanças e da Administração Pública 2007).

The Primary Health Care Mission (PHCM) was then created with the goal of implementing the new policies within the primary health care sector (Biscaia et al. 2005). Two main responsibilities were outlined. First, to "coordinate and support the global process of implementation of family health units (FHU), supporting the applications, establishing reference patterns for the contracts and also setting the indicators for the activities and services". Simultaneously, this PHCM was also responsible for "coordinating the process of launching and implementing the Primary Care Centres Groups (PCG), driving their organizational transformation into management units, following the managers' work and contributing to an

ethical culture of transparency and rendering accounts" (Missão para os Cuidados de Saúde Primários 2007c).

Before presenting a deeper analysis of the Portuguese primary care sector (section 2.3), we start by defining the role and the characteristics of the primary care sector within health systems.

2.2. The primary health care sector and its characteristics

Primary health care is often described as having an even more important role than the one of gatekeeping, which by itself is a key process in the health system (Atun 2004). In this section we provide an overview of the concept of primary health care and on its key importance in a general health system.

2.2.1. The concept of primary health care

The International Conference on Primary Health Care, organized in Alma-Ata in 1978, defined that *"Primary health care is essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination. It forms an integral part both of the country's health system, of which it is the central function and main focus, and of the overall social and economic development of the community. It is the first level of contact of individuals, the family and community with the national health system bringing health care as close as possible to where people live and work, and constitutes the first element of a continuing health care process"* (International Conference on Primary Health Care 1978).

Nowadays, primary health care is considered an essential type of care (Starfield et al. 2007), universally accessible to all individuals, and responsible for the treatment and prevention of the majority health problems of the population. Several elements are considered fundamental in primary health care: accessibility, globalism, coordination (being a key entry point in a health system, it is responsible for communicating with the other levels of health care), longitudinally (being the main health care provider through the lifetime of individuals), active participation in the community and application of epidemiological methods (Biscaia et al. 2005).

2.2.2. The role of the primary health care sector

The importance of primary health care on NHS based countries has been the subject of several debates and studies in the last decades. International studies show that the strength of a

country's primary care system is associated with improved population health outcomes for all-cause mortality, all-cause premature mortality, and cause-specific premature mortality from major respiratory and cardiovascular diseases (Atun 2004). Furthermore, increased availability of primary health care is associated with higher patient satisfaction and reduced aggregate health care spending (Atun 2004).

In low-income countries, evidence shows that expenditure on PHC is more pro-poor than aggregate expenditure that includes hospitals, and has a desirable distributive impact benefiting the poorer segment of the population proportionately more than the richer segment. Studies from developed countries demonstrate that an orientation towards a specialist-based system enforces inequity in access. In contrast, there is general agreement that expenditure on primary care improves equity (Atun 2004).

In 2004, the World Health Organization led a study about the advantages and disadvantages of restructuring a health care system in order to be more focused on primary care services. The main conclusions were that a shift of services away from specialist care to PHC allowed for lower costs, increased user's satisfaction, increased equity and did not adversely affect quality. However some questions remain about the configuration of primary care structures and teams, content of services, and modes of delivery. This work precisely represents an attempt to find solutions for these addressed issues.

2. 3. Some features of the Portuguese primary health care system and ongoing reforms

After a general review of the concept and role of primary health care, a closer look is now given to the Portuguese case, namely to its history, some features and current reforms.

2.3.1. Some features of the Portuguese primary health care system

In this subsection the main Portuguese primary health care system's features are described in order to frame the subsequent reforms.

The general practitioner

Clinical and non-clinical personnel are decisive to deliver individual and public health interventions and are one of the most important inputs in health systems. The performance of these systems depends ultimately on the knowledge, skills and motivation of the people responsible for delivering services. Furthermore, expenditure in human resources is usually the largest single item in the recurrent budget for health (World Health Organization 2000).

The analysis of available medical human resources in Portugal indicates that there were 3.4 physicians per 1000 inhabitants in 2005, which represents an increase on the previous year's ratio of 3.3. This ratio has maintained a positive growth throughout these years. The same trend, though more pronounced, is registered in the indicator that relates the number of nurses with the resident population. As we can observe in figure 1, the number of nurses per 1000 inhabitants was 4.6 in 2005, which is higher than the ratio recorded in 2004: 4.3. This indicator recorded an average annual growth rate of 5.2% between 1999 and 2005, which is higher than the growth rate of 1.3% recorded for physicians per 1000 inhabitants (Instituto Nacional de Estatística 2006b).

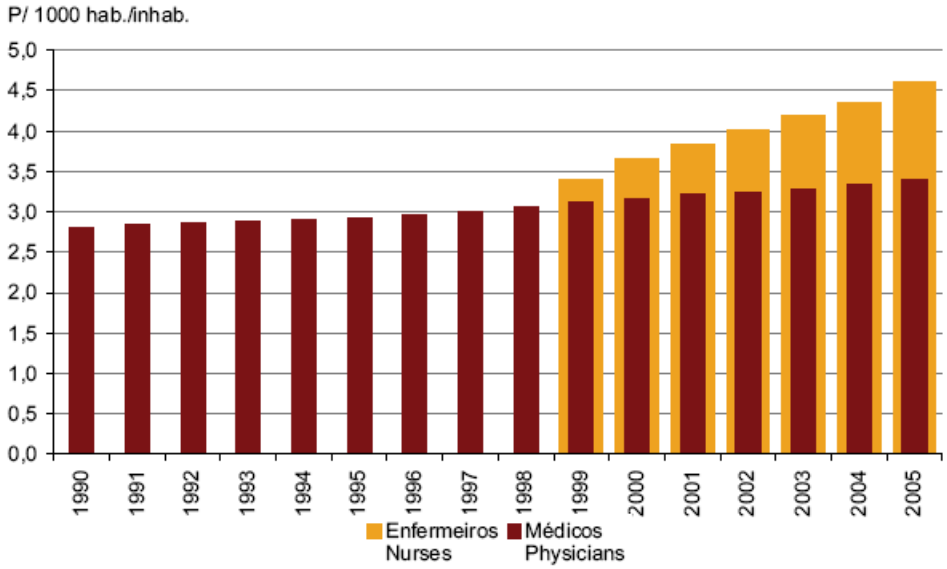


Figure 1: Evolution of the number of physicians and nurses since 1990
(Instituto Nacional de Estatística 2006b)

Comparing with other countries, the number of physicians in Portugal per 1000 population is already above the EU average. The situation regarding nursing staff is quite different. The relative number of nurses in Portugal is well below that of EU countries' average. This implies that Portugal has a ratio of nurses to physicians much lower than in most countries, probably caused by the defined activities that can be performed by nurses and by physicians. Still, recent years have witnessed a movement towards a rebalancing of this trend, with a greater increase in nurses than in physicians, and this is likely to continue in the future. One of the major challenges for the next 10 years, not yet translated into policy actions, is the redefinition of roles for health care professionals (Barros et al. 2007).

Splitting the medical class into two major categories (non-specialists and specialists), 12831 physicians out of the total registered in 2005 (36138 physicians) were non-specialists, being this equivalent to a 35.5% share of the total number of physicians (Figure 2). This share is slightly higher than the 35.1% share recorded in 2004. The non-specialized group decreased between 1990 and 1997 before inverting this trend and growing in the following period. On the other hand, the specialties with the highest number of physicians in 2005 were General and Family

Medicine (4882), Paediatrics (1427), Gynaecology and Obstetrics (1413) and General Surgery (1379). There were 26043 specialised physicians in 2005, equivalent to an increase of 3.5% on 2004 value, thus carrying on the upward trend.

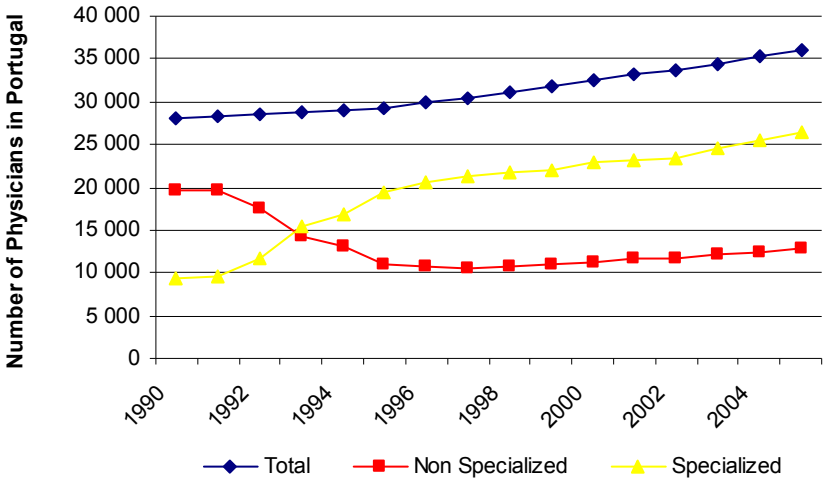


Figure 2: Variation in the number of physicians in Portugal since 1990 (Instituto Nacional de Estatística 2006b)

In Figure 3, it is possible to observe the variation in number of Nurses in Portugal since 2000 (Instituto Nacional de Estatística 2006a).

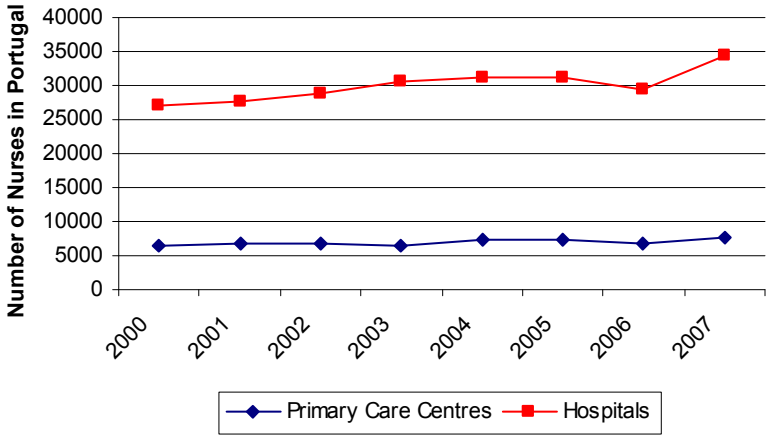


Figure 3: Variation in the number of nurses in Portugal since 2000 (Ordem dos Enfermeiros 2007)

The showed lack of nursing personnel within primary health care centers, the small and inadequate amount of doctors in some regions and specialties (e.g. GPs), and the imbalance of primary care physicians versus hospital specialists are some of the visible signs of the weakness of public health policy in the field of human resources. Moreover, the retirement in the near future of many physicians will create a shortage, as past policies did not ensure a sufficient intake to replace them. If current trends prevail, absolute numbers will become an issue in the future. Showing that an effort is being made to address the limitations in primary care, in fact, from 2004 to 2006 there was an increase of 49% in intern admissions and an increase of 42% in the number of interns in training programmes for GPs and family medicine. From a global

point of view, the intern admissions increased by 111% and the actual number in training increased by 57%. It is widely recognized that a shortage of GPs exists and that this situation is likely to worsen in the future, as current GPs start to enter retirement. Recent decisions of the Ministry of Health regarding training vacancies indicate a willingness to deal with this issue (Barros & Simões 2007).

Professional satisfaction

An individual's professional satisfaction is related with the correspondent occupation and conditions in which the work is performed. A study carried out in 2007 (Santos et al. 2007) about professional satisfaction among general practitioners in primary care centres concluded that professional satisfaction is not homogeneous. Some findings of this study were:

- The higher the ratio between the number of nurses and GPs and between the number of managers and GPs, higher the satisfaction and lower the pressure;
- High number of patients assigned to a physician leads to low satisfaction;
- The higher the number of patients with no GP, the worst the relationship with managers;
- High amount of extra time hours lead to higher satisfaction and to a better relationship with leadership.
- Sharing the office where consultations take place leads to higher dissatisfaction and higher pressure;

Primary health care centres

From the data of the Figure 4, it is possible to affirm that the overall number of primary health care centres during these last 16 years has been constant. No significant changes have occurred, except in the ratio between health care centres with and without inpatient admissions. As we can observe, it is clear the tendency for primary health care centres not to have inpatient services.

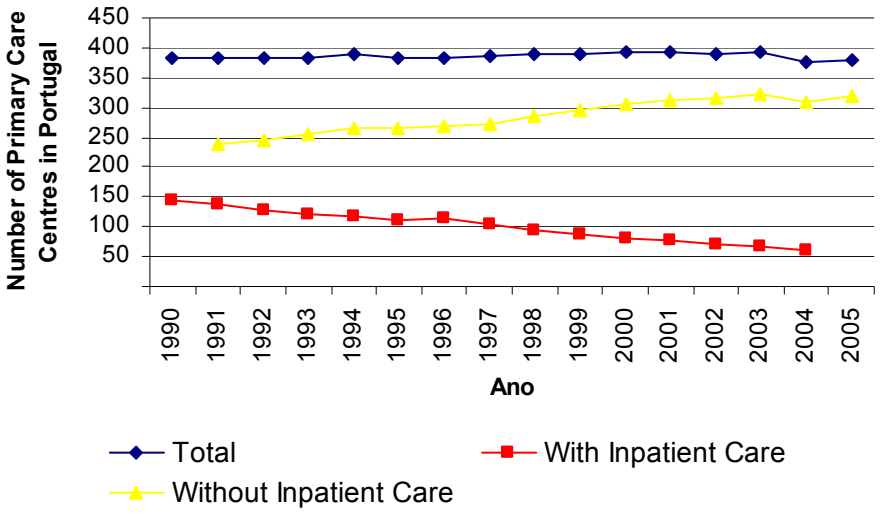


Figure 4: Evolution of the number of primary health care centres in Portugal since 1990 (Instituto Nacional de Estatística 2006b).

Number of consultations in primary health care centres

The overall number of consultations in primary health care centres, as we can observe in figure 5, has been increasing mainly since 1998. Here, adult consultations are clearly the dominant type of appointment, representing around ten times more that of others. Moreover, there has been an increasingly larger delivery of child health care (almost three million consultations now) which leaves no doubts about the role of primary health care centres and family physicians in delivering care to the youngest in society (Branco & Ramos 2001).

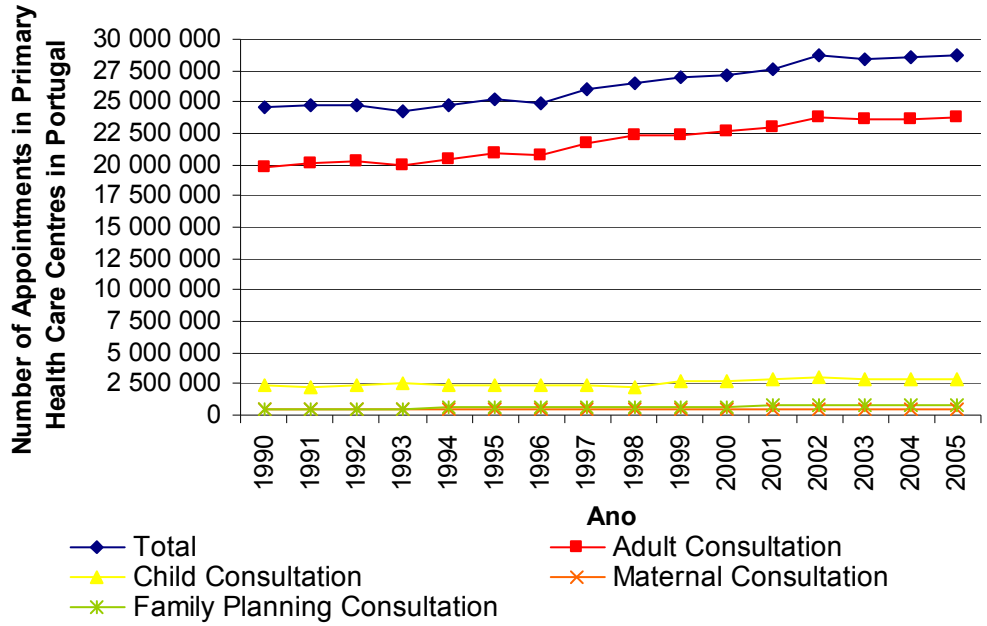


Figure 5: Variation in the number of appointments in primary health care centres in Portugal (Instituto Nacional de Estatística 2006b)

Thus, regarding what was previously said (namely the overall number of primary health care centres being constant and the increasing overall number of consultations in these units) it is possible to take some conclusions. Inevitably, the demand and pressure put on primary health care centres will increase, leading to an increasing need for more physicians, nurses and managers, higher stress for the existing working personnel and higher waiting times for patients. This current situation consequently leads to higher dissatisfaction for patients and medical personnel and to a decrease on the quality of the healthcare output. In order to invert this trend recent reforms have been implemented.

Accessibility to health care

One of the results of the deep changes within the social and demographic context during the last two decades has been the crescent increasing percentage of urban population (mainly suburban). Between 1980 and 2004 this percentage changed from 29,4 to 55,1% which led to another phenomenon – a change in the accessibility to health care (Campos 2008). Together

with the lack of planning within the health care network, which led to no changes on the resources' allocation, these two facts have been triggering the increasingly high number of citizens without a GP and an unnecessary overuse of the emergency services of hospitals (Campos 2008).

Equity in Portuguese health care

Primary health care have shown very good results in reducing health disparities both in developed and underdevelopment countries (Atun 2004).

One of the actual dilemmas within the present model of the Portuguese NHS concerns whether and how is it possible to respond to the increasing of costs and, simultaneously, promote actively the equity so that social, economic, geographic and cultural inequalities are attenuated (Campos 2008). With the aim of extract the precise equity objectives of one health care system, that of Portugal, a study was performed by (Pereira 1990). Three seemingly distinct objectives in Portuguese health policy were identified: access to health promoting commodities; equal access to NHS care for equal need; and equal access to both public and private health care. Moreover, from the study of the equity in physician's utilization in 21 OECD countries, in 2000, it was found that the degree of pro-rich inequity in doctor use in Portugal is one of the highest among the studied OECD countries (Doorslaer et al. 2006). Thus, despite the long tradition of health care policies directed to the system's performance, to the professional's status and NHS reform, improvements are needed so that the central point of the system becomes the patient (Campos 2008).

Summary of the main present challenges in the Portuguese primary health care sector:

- The showed lack of nursing personnel, the small and inadequate amount of doctors in some regions and specialties (e.g. GPs), and the imbalance of primary care physicians versus hospital specialists are some of the visible signs of the weakness of public health policy in the field of human resources.
- The retirement in the near future of many physicians will create a shortage, as past policies did not ensure a sufficient intake to replace them. If current trends prevail, absolute numbers will become an issue in the future. It is imperative a better use of the existing human resources.
- The crescent increasing percentage of urban population (mainly suburban), between 1980 and 2004 together with the lack of planning within the health care network, led to a very high number of citizens without a GP, to unnecessary overuse of hospitals' emergency services (Campos 2008) and higher dissatisfaction within patients and medical personnel.

2.3.2. Ongoing reforms on the Portuguese Primary Health Care System

A review of the main Portuguese primary health care's reforms and history is presented in the Appendix 1. This review allows us a better understanding and framing of the reforms that are being studied on the present work. The ones that concern us the most are the ones related with the shifting of primary health care centres into family health units.

Primary health care centres (PHCCs)

The first generation of primary health care centres (PHCCs) was created in 1971 with the "*Gonçalves Ferreira Reform*" and with the Law 413/71. They were responsible not only for the prevention of certain contagious diseases through several vaccination campaigns but also for the assistance of more vulnerable groups like pregnant women and children (Branco & Ramos 2001). Around 1983, after the creation of the Portuguese NHS and the introduction of the general practitioner career, the second generation primary care centres were formed (97/83 Dispatch). They were the result of the merge of the first generation primary care centres, the "*Serviços Médico-Sociais das Caixas de Previdência*" and the municipal hospitals (Branco & Ramos 2001; Gouveia et al. 2007a). Despite some gains in the resource optimization and rationality, this whole model revealed to have a centralized management from the Regional Health Authorities, becoming impossible to answer the existent expectations and needs, and leading to an increasing number of unmotivated and dissatisfied professionals. (Branco and Ramos 2001). This way, a first attempt to change this situation was made in 1996 with the Alpha Project. Two years later, the Experimental Remunerative Regime (ERR) was created for general practitioners (Ministério da Saúde 1998). Both these reforms tried to distinguish those GPs whose services were more team oriented and that had a higher performance in quality and accessibility. The goal was to fight the increasing number of patients without a general practitioner, the inadequate timetables, long waiting times and excessive use of expensive technology and prescription of drugs (Direcção Geral de Saúde 2004). Despite these attempts, the most common form of payment in primary health care centres is still the monthly salary. This way, in these units, the majority of personnel's remuneration is ruled by the 42 hours/week public administration's legislation for the correspondent sector and career. Each of these units embraces a certain pre-defined region and the correspondent catchment's population (reached population). Each physician has his own list of patients, for whom he/she is responsible for. Acute/urgent situations are taken care of, independently, by the complementary service. However, increasingly often, physicians' lists are full, leading patients without a GP. Thus, these patients usually have to be redirected to complementary services in order to be taken care of contributing to a more distant relationship between the patient and the physician and to the overuse of those acute services.

Family health units

Regarding the problems and challenges that the primary health care sector, more specifically primary health care centres, were facing (previously referred), reforms initiated in 2005 allowed for the definition, launching and implementation of the innovative family health units (FHU). These units were described as “the organizational elementary cells on the individual and family health care provision, formed by a multi-professional team with organizational, functional and technical autonomy, integrated within the other functional units of the primary care centre” (Ministério da Saúde 2006).

This Law legislated the existence of a committee responsible for not only accompanying and controlling these FHUs but also for linking provision of care in NHS units to health care financers. Thus, along with the Contracting Agency (CA), the Primary Health Care Mission (PHCM) was made responsible for establishing a set of indicators and goals for these FHU and to assess the results obtained. Analysis of performance of FHUs aimed at evaluating the impacts of the reform and promoting motivation, responsibility and accountability to changes in the primary care sector. Indicators used by the CA were grouped in 4 categories: access, productivity, perceived quality and economic performance (Agência de Contratualização dos Serviços de Saúde 2006).

As mentioned earlier, each FHU integrates a multi-professional team formed by general practitioners, nurses and managers, and its size depends on the list of patients registered in their lists. The total number of patients associated to each unit might vary from 4000 to 18000. Each patient and his family (if possible) are assigned to a single GP and the minimum number of patients assigned to each doctor is around 1550, which corresponds to 1917 weighed units. Children from 0 to 6 years old contribute to this weighed units with a factor of 1.5, adults between 65 and 74 years old with a factor of 2 and adults older than 75 with a factor of 2.5. Family health units opening hours are usually from 8 am to 8 pm, only during the week. This timetable can be changed within the RHA if properly justified.

With these new primary health care reforms, the continued improvement on quality became a fundamental objective. So, it was imperative for government to create a model of incitement not only to doctors but to all FHU professionals, rewarding the individual and collective performance. With the Law 298/2007 two types of incentives were created: financial and institutional. Both could be achieved as a result of the number and characteristics of the patients assigned to each doctor’s list, the number of specific vigilant activities on more vulnerable groups, enlargement of the period of assistance and other additional services (Ministério da Saúde 1998).

FHUs can be organized according to three different models – A, B or C. While some of these units may seek for higher autonomy, others may prefer to be more stable in a less complex

level. As explained in (Missão para os Cuidados de Saúde Primários 2007a) the two main remuneration models are:

- Model A – in these FHUs all the personnel's remuneration is ruled by the public administration's legislation for the correspondent sector and career. Moreover, there is the possibility to negotiate an additional set of services, paid as extraordinary work, under the rules of the correspondent law. Similarly to the other models (B and C), it is possible here to negotiate with the Contracting Agency the achievement of certain goals that can lead to further institutional incentives for the FHU.
- Model B – the remuneration process in this type of FHU is formed by two components: a fixed and a variable one. The fixed component corresponds to the legislated remuneration for an exclusive 35 hours/week period. The variable one corresponds to all supplements and compensations that derive both from the worker's performance and from the health care unit's results.
- Model C – this model is hybrid between public and private management. It can either be a public FHU with some private contracts for some specific services, or a private FHU which activities depend on previously set up contract with the Regional Healthcare Administration. This model has not been used yet.

In this way, it is expected that these multi-professional teams working in an organizational context with accountability and being paid by production will contribute for improvements within the Portuguese primary care sector (Missão para os Cuidados de Saúde Primários 2007b), namely have a potential increase on the patient's accessibility for consultations (Missão para os Cuidados de Saúde Primários 2008). Moreover, the opportunities created by the new model in terms of the organization of work seem to stimulate the autonomy of decision which, together with the teamwork and inter-substitution, is likely to increase the satisfaction and motivation among the health care professionals that work here.

Summing up, this reform of creating FHUs in Portugal is a clear attempt to overcome the presented challenges within the primary health care sector, in order to increase the associated accessibility, efficiency and quality.

In the next chapter, we will start by reviewing the Portuguese literature regarding the ongoing reforms, and then we will present the set of reforms that have been carried out in some foreign developed countries.

3. Review of ongoing reforms in the primary health care sector and their impacts

This thesis proposes the use of discrete event simulation models to compare the performance between two organizational types of primary care units – Family Health Units vs. Primary Health Care Centres – and to test the impact of extending current reforms. We have explained in chapter 2 that family health units are the result of a set of innovative reforms recently implemented by the Portuguese government in the primary health care sector. This chapter aims at reviewing the Portuguese literature, describing how other countries have been reforming their primary care sectors, which information is available on the impact of those reforms, and how available studies have quantified the impact of reforms in the primary care sector.

Three studies reviewed the latest reforms within the Portuguese primary health care sector (Biscaia et al. 2005; Branco & Ramos 2001; Gouveia et al. 2007b). Biscaia et al. have analysed the satisfaction of patients and physicians as well as the priorities for the current primary health care reform (Biscaia, Martins et al. 2005). Results suggest that one of the most critical points of the present reform is the improvement of patients' and professionals' satisfaction mainly through a closer relationship between these two entities. Another study has analysed the cost differences between primary health care centres and Experimental Remuneration Regimen (ERR) units (Gouveia et al. 2007a). It consisted on an econometric analysis that confirmed the existence of a self-selection trend for ERR units' physicians to carry out a higher number of consultations. Moreover, it was estimated an overall reduction for these units' costs (resulting from an increase on costs with medical personnel compensated by savings within drug prescriptions and complementary diagnosis tests). This study was later completed by an econometric analysis of the costs, remuneration and incentives associated with family health units (Gouveia et al. 2007b). Results pointed for an increase in costs associated with the remuneration and incentives' system of physicians. Pisco (Pisco 2007) also conducted a study about the present reconfiguration of the primary health care sector and evaluated the necessary steps in order to successfully implement primary health care centres' groups. A more recent study has focused upon the problems and successes from implementing new FHUs (Missão para os Cuidados de Saúde Primários 2008), listing the set of successes and areas where an intervention was needed in order to this reform to be fully successful. Regarding equity, previous studies demonstrated that despite the Portuguese health care system's orientation for an equal access to the NHS, to health promoting commodities and to both public and private health care (Pereira 1990), the degree of pro-rich inequity in doctor use in Portugal is one of the highest among the studied 21 OECD countries (Doorslaer et al. 2006). Regarding the efficiency, (Campos 2008) referred that positive signs from the ongoing reform of implementation of FHUs started to be visible at the end of 2007, namely the reduction of consultations' demand outside the normal working period of health care units, a closer relationship between the patient and the

physician and a higher degree of satisfaction and motivation among users and medical personnel. A review of a number of available action plans and activity reports from several FHUs pointed out similar efficiency improvements (USF Dafundo 2008; USF Delta 2008; USF Marginal 2008; USF Rodrigues Migueis 2008; USF Tílias 2008). Regarding tools that might be used to test new policies, a stochastic discrete event simulation model to study the organisation of primary and secondary care services was recently proposed by (Farinha et al. 2008). Results showed that although the current system is not prepared to cope with a rise in demand, other tested scenarios indicate that there is room for primary care reforms to increase the system's efficiency and accessibility, while lowering total costs. It is important to emphasize that from all the studies referred above only the last one used simulation as a tool.

We now present a brief review of important ongoing primary care reforms, similar to the ones being implemented in Portugal, within NHS and non-NHS foreign countries. On Canada, for instance, since 1998, significant changes have been applied in its primary health care network. Within the United Kingdom, a NHS based country, several important primary health care reforms have been implemented during the last decades. We will present two of the most relevant and recent reforms: the creation of Primary Care Groups (later Primary Care Trusts) and the introduction of incentive-based contracts for general practitioners.

3.1. Literature review on ongoing reforms in the primary care sector

During the last decades several initiatives have shown that there is room for experimentation and new reforming attempts, producing extensive experience on possible policy options to solve well known problems inside primary care (Wienke et al. 2006). However, regulating health care and carrying out reforms are complex tasks as they depend, among several factors, on the motivation of diverse professionals within the health care system to positively respond to changes.

Lately, the field of primary health care has witnessed a variety of experiments and a diversity of different organizational similar changes. The diversity of reforming strategies has reflected the specific characteristics of the primary care field, such as the functional, institutional and structural differences observed in these countries. Despite this plurality, three main types of reforms have been defined (Wienke et al. 2006):

1) Organizational reforms that give primary care more power and control over other levels of care: these reforms typically involve primary care professionals (GPs, nurses) and/or organizations (e.g. primary health care centers) in the process of extending primary care's reach to gatekeeping, which restricts the provision of unnecessary hospital services. A prominent example of these new levers has been the introduction of GP-fundholding schemes in the UK, which devolved purchasing power to the primary care level. This

fundholding experience has received generally positive evaluations regarding its impact upon efficiency (Glennester et al. 1994). Other experiments where primary care professionals were given varying degrees of power have been observed in the 1990s in Sweden, Germany, and Italy (European Observatory on Health Systems and Policies 2005).

2) Organizational reforms that extended the range of services and/or the functions of primary care: these reforms expand the tasks/responsibilities of primary care professionals to include new services or services previously delivered by other levels of care (Evans 1994).The new services that might be offered in primary care level may vary from health prevention and promotion related services to minor surgeries or specialized diagnostic services.

3) Reforms related to supporting conditions: these reforms often involve a mix of new mechanisms and/or related organizational changes. Here are included the changes in the technological (e.g. telematics, diagnostic, or therapeutic) and human resources (e.g. new training and skill-mix arrangements) employed in the primary care settings. These reforms might also involve measures targeted on particular organizational dimensions, modifying the public/private mix, promoting team work, regulating to cover for new services, incentives to improve coordination with other levels of care, cost-sharing schemes that encourage increased use of primary care for first contact care, and measures that increase the quality and responsiveness of service provision.

As it was explained in the previous chapter, several innovative changes are associated with the ongoing Portuguese primary health care reform: the launch of FHUs formed by multi-professional teams with organizational, functional and technical autonomy, new rules on affecting patients to GPs and the implementation of institutional and financial incentives on these new primary health care units. We will now present a review of previous works related to the creation of multi-professional teams and use of incentives.

Regarding the multi-professional teamwork, it is possible to affirm that this practice has become a common strategy in trying to solve the problems created by the rising of demand and costs within the primary health care (European Observatory on Health Systems and Policies 2005). Good teamwork is thought to enhance the quality of care, constrain costs, and to make the best use of limited human resources. Quality improvements are pursued through increased coordination of health care delivery and by the opportunity for specialization within larger and more diversified teams. Primary care teams may be improved through the inclusion of medical specialists, therapists, or social care workers – this strategy has been developed in Finland. Other countries are moving in a similar direction. The United Kingdom, for example, saw a marked rise throughout the 1990s in the prevalence of general practices with a mental health

counsellor and “outreach” clinics staffed by hospital-based medical specialists (European Observatory on Health Systems and Policies 2005). The Netherlands has introduced policies to enhance collaboration among GPs, primary care psychologists and social workers (Wienke et al. 2006). Evidence suggests that a better use of the short number of human resources in several countries is pursued by trying to allocate professionals where their skills can best be used. Countries such as Italy, the Netherlands and the United Kingdom have already accepted that they should develop larger and more diversified multi-professional teams, and have started reforms consistent with that direction.

Regarding the influence of payment systems on primary care several studies show that remuneration and financial incentives do influence the behaviour of primary care organizations (Susan Langham et al. 1995). However, it has to be noticed that the experience of one country with payment systems and financial incentives cannot easily be reproduced in another country – even in the case where there is a high degree of cultural and institutional similarities.

Three main types of remuneration system exist: fee-for service, salary or capitation. Available evidences suggest that fee-for service payment systems tend to increase the volume of services provided to patients, which can be harmful and costly to society and lead health authorities and/or health insurers to try to limit the volume of these services (Starfield et al. 1994). In the UK, for example, studies show that combining a capitation payment for GPs, with a salaried one for specialists leads, in one hand, to a higher risk of having waiting lists for specialist care. On the other hand, when combining capitation payment for GPs with a fee-for-service payment for specialists, there will be an excessive referrals and high spending in specialist care (Adams et al. 2001). Thus, policy-makers should be careful to provide the adequate remuneration system that leads to high income security for primary care physicians, high accessibility for patients and low transaction costs for society (Adams & Hicks 2001).

3.2. The Canadian primary health care reform

The primary health care reform being implemented in some provinces of Canada (since 1998) has been creating family health networks to improve the deliver of primary care. Groups of physicians are being created, supplemented with a nurse-staffed telephone service 24 hours a day, so as to deliverer comprehensive care while promoting a stronger doctor-patient relationship (Fooks 2004). The elements that are characterizing this ongoing reform are:

- *Team approach to service delivery*: some provinces begin with the family physician and built other providers around the physician, whereas other Canadian provinces started with a nurse or nurse practitioner and used medical resources at the next stage of contact.

- *List of patients*: there is a general desire to get patients registered within a specific group practice or team of providers. There appears to be several types of formality about this aspect of reform with some provinces talking about “sign-up” periods and others not limiting patient movement amongst difference providers in any way.
- *Twenty-four hour access, seven days a week*: together with the primary care unit, there is commitment for an after-hours access to a nurse by telephone.
- *Mixed funding formulas for services and programs*: some fairly moderate experimentation funding formulas have been proposed in new funding models mixing capitation, salary and combinations of both with fee-for-service payments. A number of provinces are proposing to move to a population-based funding model linked to specific demographic and health characteristics of enrolled populations.
- *Increased emphasis on health promotion and prevention*: all the provinces’ policy materials emphasize a focus on health promotion and prevention.

However, the report (Ontario Ministry of Health and Long Term Care 2004) alerted for some possible barriers for the success of this reform. They were divided in three categories:

- The legacy of Canadian health policy culture: Embedded within the history of physician payment in Canada is the legacy of paying physicians on a fee-for-service basis. Physicians entered Canadian medicare on the basis of existing fee schedules – a price for each service delivered. Although some experimentation has occurred over time, and physicians have indicated an increasing willingness to consider alternative forms of payment (Canadian Medical Association 2003), fee-for-service is still the primary way in which primary care services are funded. Alternate payments only account for 11% of total clinical earnings in Canada (Canadian Institute for Health Information 2003).

- The structure and design of Canadian health care: Although primary care design is being advertised as an integrated reform, a closer look at current implementation plans indicates that this is not the case. Funding models or provincial health professions regulatory frameworks are not structurally supportive of primary care reform. Federal funding covers only portions of the comprehensive services being covered by primary care. On the regulatory side, health professions legislation is based on distinct professions with their own educational requirements, practice standards and regulatory colleges. Professional liability schemes are focused on individuals rather than teams and are legally based on professional autonomy rather than shared accountability. Finally, increased specialization and calls for continually higher levels of educational certification as entry qualifications to practice are increasing.

- The support required for policy implementation: Health human resources planning has become an urgent policy issue for the Canadian health care system in the last five years. In particular, national strategies for physician and nursing personnel have been recommended. However, without a stronger link between national health human resource planning and local primary care delivery, implementation of primary care may be less than optimal. For example, a greater use of nurse practitioners is clearly a goal to be achieved but to date increased training slots and new funding models have not materialized.

This way, despite all the initial difficulties in implementing these news policies, several factors show an increasing interest on them and on their results (Fooks 2004). These factors include:

- there is an evidence-base for several elements of the reform packages;
- citizens are interested in comprehensive and accessible primary care services;
- a growing number of health professionals are expressing interest in new models of care and are participating in projects;
- the required supports are coming on-line, albeit slowly.

3.3. The United Kingdom primary health care reform

Over the last decade, United Kingdom's governments' policies have placed a common increasing emphasis on the notion of a primary-care-led NHS, with an attempt to shift power and resources from secondary to primary care (Somerset et al. 1999). Initiatives such as fundholding, total purchasing pilots, Primary Care Groups (PCGs), and the pilot salaried schemes have attempt to shift resources to the primary and community sector, and away from the hospital sector (Coulter et al. 1997).

The most significant reforms were the introduction of fundholding schemes and later on the introduction of PCGs. Fundholding was introduced in the NHS in the early 1990s as a result of the creation of the internal market by the Conservative Government, and were replaced in the latter part of the 1990s by PCGs and PCTs (changes under the Labour Government) (Dixon 2003).

A national network of PCGs was established in England in 1999 with three main functions: to improve the health of the population in the PCG, to develop primary and community health services within the PCG and to commission secondary and tertiary services for the population in the PCG. However, PCGs were considered to be the first stage of a process, resulting in the eventual transition to PCTs (Primary Care Trusts) (Mays et al. 1998). PCTs had the same functions as PCGs, but a greater range of responsibilities. In April 2002 around 300 primary care trusts were formed with the mission of improving the health of the community, developing

primary and community health services, and commissioning secondary care services, representing approximately 80% of the health care budget.

An improvement on this reform was recently introduced (a practice-based commissioning). From April 2005, practices can receive an “indicative budget” from Primary Care Trusts which they can use to improve the delivery of services. The case study sites where such schemes have been tested suggest that patients will have access to alternative pathways of care across primary and secondary care (Wienke et al. 2006).

Another important reform, similar to the Portuguese one, was introduced within the United Kingdom in 1983 when the Royal College of General Practitioners adopted a goal that within 10 years, all GPs should incorporate standard setting and performance reviews as an integral part of their professional lives. In 1991 medical audit advisory groups were created to support and facilitate audit by all GPs and primary health care teams. Limited funds were provided to allow these groups to function. In 1998, a new mandatory system was introduced, that incorporated audit into a broader set of quality improvement activities. At the same time, a national body for guideline development was created. Since then, other national agencies have been playing an essential role developing patient’s safety. In 2004, a major development in quality improvement took place. A new incentive-based contract for general practitioners was introduced, where payments were linked to the achievement of certain targeted conditions and to the assessment of patients’ experiences. This is probably the most advanced example to date of a reform defining quality of care and the transfer of power to determine quality from professionals to planners. Results suggest that, although it has risks, many of its design features accord well with the principles of incentive design advocated by economists. If the contract is implemented and evaluated with care, and necessary adjustments are made as experience is accumulated, the new GP contract offers the prospect of enormous gains in the quality of primary health care in the United Kingdom and can inform policy in many other types of health systems (Smith et al. 2004).

After this previous review of primary health care reforms in NHS and non-NHS countries, similar to the current Portuguese one, and giving some example like Canada (non-NHS) and United Kingdom (NHS), we will present in the next chapter the methodology used to compare the performance of FHU and PHCC organizational models. We propose the use of discrete event simulation models to compare the performance. As we will observe, these new FHUs have several similarities with the presented Ontario’s family health networks, British Primary Care Groups (PCTs) and incentive-based contracts for general practitioners.

4. Methods to analyse the impact of primary health care reform and the proposed simulation model

The main purpose of this thesis is to develop methods to quantify and analyse the impact on efficiency, quality and costs of the policy reform of creating FHUs in Portugal. We first discuss the range of methods that are available to analyse the impact of this reform is initially made. Secondly, we explain why we consider discrete event simulation to be an appropriate method for answering to the research questions defined in this thesis. Then we describe the simulation models developed in this thesis: we describe the conceptual model, the application of the model to the Portuguese primary health care system, as well as discuss validation issues.

4.1. Available methods to analyse the impact of the primary health care reform

A system is defined to be a collection of entities (e.g., patients) that act and interact together toward the accomplishment of some logical end (Schmidt et al. 1970). There is often a need to study systems, in order to understand the relationships among the various components or to predict performance under some new conditions being considered. In the present work, our system will be a component of the Portuguese NHS, namely the Portuguese primary health care sector.

As we can observe in the following figure, there are several different ways to study a system:

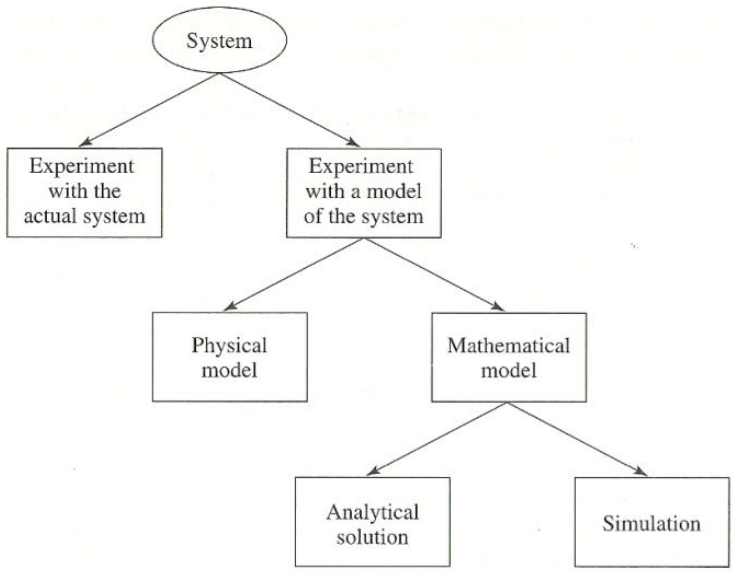


Figure 6: Ways to study a system (Law 2000)

According to Figure 6, the first question to ask when choosing the best way to make new experiences in a system is whether we should test changes in the current system or in a model.

The following paragraphs describe the type of models that we might choose following the answer to some sequential questions.

Experimenting with the actual system vs. Experimenting with a model of the system: Altering the current system and operating it under new conditions is usually the most desirable way to study systems because no questions arise about its validity. However it is rarely feasible to do this, because it often becomes too costly or too disruptive for the system. This problem commonly applies to policy experiments. In this way, it is usually necessary to build a model as a representation of the system and to study the system as a substitute for the current system. However, when using a model, there is always the question of whether it accurately reflects the system for the purposes of the decisions to be made (model validity) (Law 2000). Two main types of models can be created: physical or mathematical models.

Physical model vs. Mathematical models: Physical models are models that represent faithfully the real system being studied, usually in a different scale. They make use of physical laws in order to recreate the behaviour of certain real systems. However, the majority of the built models are not physical but mathematical, representing a system in terms of logical and quantitative relationships that are manipulated and changed in order to observations of the system, and how the model reacts. Thus, mathematical models are used to study how the system would react to some exogenous and structural changes (assuming that the mathematical model is a valid one) (Law 2000). Inside mathematical models, two possible solutions exist: analytical solutions or simulation.

Analytical solution vs. Simulation: If the model is simple enough, it may be possible to work with its mathematical relationships and quantities in order to obtain an exact, analytical solution (such as developing linear mathematical programming models). These methods are good in that an optimal solution is computed by the model. However, many systems are highly complex, making it impossible to create useful mathematical programming models. In this way, it becomes impossible to achieve an accurate analytical solution, leading us to the alternative use of simulation models.

The complexity of primary care providers (operating within the Portuguese Primary Health care sector) and the objectives of this study (compare the performance of family health units vs. primary health care centres) lead to the use of simulation models.

The following sections describe in detail what is simulation and the range of simulation models that might be developed. We present the underlying reasoning that lead to the choice of discrete event simulation models in our study.

4.1.1. Definition of simulation

Simulation, according to (Shannon 1978), is “the process of designing a model of a real system and conducting experiments with this model for the purpose of either understanding the behaviour of the system and/or evaluating various strategies for the operation of the system.”

Computer simulation methods have been developed since the early 1960s and are the most commonly used analytical tools for management science. The basic principles are simple enough. The analyst initially builds a model of the system, writes computer programs which embody the model and then uses a computer to imitate the system’s behaviour when subject to a variety of operating policies. From this process, it is possible to select the most desirable policy.

In a computer simulation we use the power of a computer to carry out experiments on a model of our system. In most cases, such simulations could be done by hand – but few would wish to do so. Given that computers offer a significant power for a minimal cost, the use of computer simulation approaches has been increasing in management science.

4.1.2. Types of simulation models

Simulation models can be classified according to several criteria:

- Management of time: can either be done through a time-slicing mechanism or through events. Using events, all variables of the model are actualized whenever an event takes place.
- Degree of randomness: can either be a deterministic or a stochastic simulation model. Deterministic simulation models are characterized for not considering random variables. All parameters and relationships that describe the model are known. As opposite, stochastic models correspond to those where at least one of the variables is random, being described by a probability distribution (Nova 2000).
- Continuous or Discrete Simulation Models: continuous simulation models correspond to those where the state of the systems is described by variables that continuously change during the time. Discrete models are described by variables that change their value in isolated instants during time (Nova 2000).

4.1.3. Applications of simulation

Simulation models have being applied to several areas. A review of some of these areas allowed us to observe that within the health sector (Lagergren 1995) the following areas of modelling applications can be distinguished:

1) Epidemiology, health promotion and disease prevention:
    a) Prediction of incidence, prevalence and mortality for specific diseases,
    b) Evaluation of intervention strategies or disease control programmes,
    c) Evaluation of screening programmes;
2) Health and health care systems design:
    a) Estimating future resource needs,
    b) Capacity planning of hospitals,
    c) Business planning approaches,
    d) Design of emergency services;
3) Health and health care systems operation:
    a) Appointment systems, waiting lists and waiting times,
    b) Staff scheduling,
    c) Prediction of short term demand,
    d) Planning of auxiliary services,
    e) Evaluation of medical technology.

Additionally, according to (Royston 1995; Vissers 1998), it is possible to apply simulation models to the following health care sector areas: (a) forecasting the demand for health care; (b) securing the required health care resources to fulfil that demand; (c) allocating health care resources to providers of health care; (d) developing programs and plans of the way resources will be actually used for health care delivery; (e) developing criteria (standards, targets) for health care delivery performance; (f) managing the performance of health care delivery; (g) evaluating the results of health care delivery.

The present study consists on the development of a discrete event simulation model to compare the performance of two types of primary health care units (family health units (FHUs) vs. primary health care centres (PHCCs)), and can be classified either into Lagergren's health and health care systems operation area or in Royston's managing the performance of health care delivery area. However, despite all the reviews carried out, no national or international studies were found concerning directly the use of a discrete event simulation models to evaluate primary health care organizational reforms. The closer we got, were some studies that describe how simulation can be used to test alternatives and choose a solution to significantly reduce the length of stay for patients within an emergency department (McGuire 1994). Simulation models that were used in the design of appointment systems to minimize patient waiting times (Dexter 1999) and a tutorial that presents example applications of simulation in some specific services within the health care sector (Farrington et al. 1999). Concerning the Portuguese reality, a stochastic discrete event simulation model to study the organization of primary and secondary care services, with reference to the context of the Portuguese NHS, was proposed by (Farinha et al. 2008).

Thus, our study differs from previous studies in that we compare two organizational models of primary care using simulation models, and quantify some impacts of extending the FHU model to the primary health care sector in Portugal. Given that this research answers to policy questions that are of extreme relevance to policy makers, we consider that our work has the potential to contribute to enhancing research in health services.

4.1.4. Why choosing a Discrete Event Simulation (DES) model?

The goal of this work is to simulate and assess the performance of two distinct models of organization of the Portuguese primary health care units (primary health care centres vs. family health units). The way these health care units operate, evolves over time, in different ways. The constant flux of patients, doctors, nurses and managers inside them is different for each model and implies different processes through time, and there is uncertainty concerning some values in the system (that is the case for demand for primary care). Consequently, in order to describe this system faithfully, random variables should be considered. Besides demand, the length and the waiting time for a consultation should not be considered fixed in the system, which means that the model should consider stochastic elements. Finally, the events of this system can be described as occurring in individual and isolated instants of time which makes the model discrete – for example, patients are the units that enter into FHUs and PHCCs as counting events throughout time. For these reasons, we propose to use a dynamic, discrete event stochastic model, also known as DES.

Discrete-Event Simulation models include state variables that change instantaneously at separate points in time. These points are the ones at which an event occurs, being an event defined as an instantaneous occurrence that may change the state of the system. As an example of events we may have: a patient entering the primary health care unit, a physician carrying out a consultation or a patient leaving the primary health care unit.

Although DES could conceptually be developed by hand calculations (analytical), the high amount of data that must be stored and manipulated for most real world systems dictates that discrete-event simulations must be done on a digital computer (Law 2000). Several simulation software are available in the market with different characteristics: SIGMA, Simula, SimEvents, Simul8, etc. From all these packages, we chose to work with Simul8, due to the fact of being one of the most globally recognised simulation softwares for Business Process Simulation (Simul8 Corporation 2000) but also because of the previous positive experience of the authors with it.

4.1.5. Modelling a problem

In order to develop a discrete event simulation model, the analyst must follow a set of steps that are appropriate for dealing with multiple aspects and levels of detail of a complex real-world system that should be incorporated into a simulation model (whereas some aspects can be safely ignored). Having a one-to-one correspondence between each element of the system and each element of the model might result in an excessive model execution time, missed deadlines, or in obscuring important system factors (Law 2000).

While building a simulation problem, three main phases are involved: Problem Structuring, Modelling and Implementation (Pidd 2004). These are shown in Figure 7 and then described in detail.

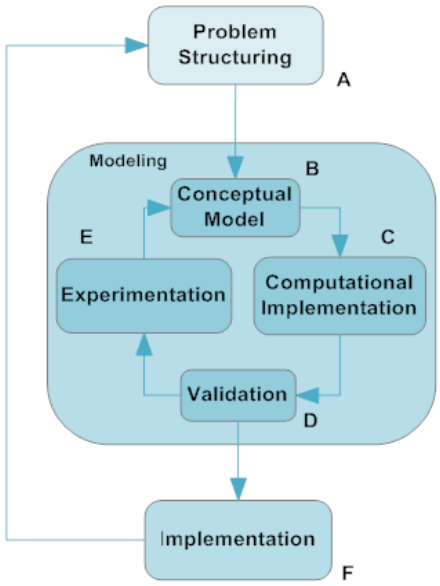


Figure 7: Diagram of the several steps in a simulation problem.

A – Problem Structuring: represents an attempt to understand the issues which are being addressed to the project under analysis in an effort to decide what kind of detail will be appropriate. It constitutes the process where the analyst must collect and interpret preliminary data so as to learn enough about the problem and how to proceed.

Modelling: after problem structuring, building a computer simulation model demands usually for four tasks: conceptual model building, computer implementation, validation and experimentation.

- *B – Conceptual model building*: in this task the analyst tries to capture the essential features of the system that is being modelled in a general model. The first of these features is the method by which the system is to be simulated. If discrete simulation is

being used, then the aim will be to identify the main entities of the system and to understand the activity cycle diagrams. The second feature is the set of conditions within which the simulation model is to be used (Pidd 2004).

- *C – Computer implementation*: this step is usually done after building the concept model. It consists on building a computer program or using proper simulation software in order to simulate our system. In this present work, we used the Simul8 software

- *D – Validation*: is the process by which the modeller (and the model user, if applicable) agree that the model, as implemented on a computer, is suitable for use within its defined experimental frame. Trying to determine whether a simulation model is an accurate representation of the actual system being studied is one of the most difficult tasks of an analyst. Three important terms are related to this process: verification, accuracy evaluation and credibility.
    - *Verification* is concerned with determining whether the "assumptions document" has been correctly translated into a computer "program".
    - *Accuracy evaluation* is the process of determining whether a simulation model is an accurate representation of the system, for the particular objectives of the study (Fishman et al. 1968). If a simulation model is considered "accurate", then it can be used to make decisions about the real system. The ease or difficulty of the validation process depends on the complexity of the system being modelled.
    - A simulation model and its results have *credibility* if the manager and other key project personnel accept them as "correct" (Law 2000).

- *E – Experimentation*: the reason for building a simulation model is to use it as a vehicle for experimentation, often in a 'trial and error' way to demonstrate the likely effects of various policies. The experiment must be planned so that the various factors which may influence the results can be distinguished. In this way, the experimenter can determine statistically which factors give rise to which effects and may be able to draw appropriate conclusions about the effect of the policies being simulated on the system. During this experimentation step, it is crucial to define the adequate amount of time the simulation model should run in order to achieve statistically significant results. This amount of time is called warm up time (Figure 8). It corresponds to the time the simulation will run before starting the collection of results. This allows, for example, queues (and other aspects within the simulation) to get into the conditions that are typical and real for system we are simulating (Simul8 Corporation 2000).

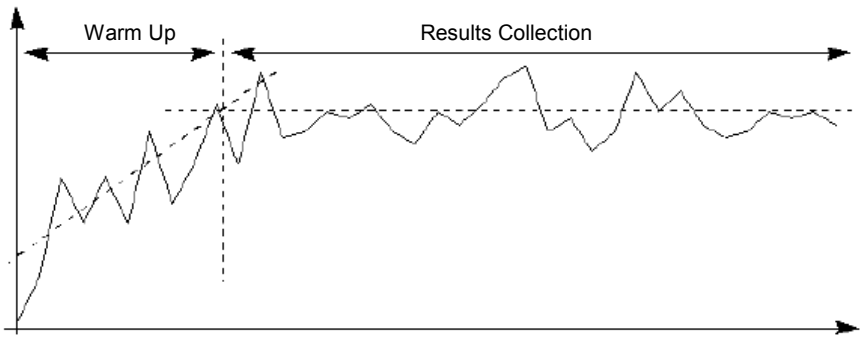


Figure 8: Representation of the warm-up period and results collecting period (Farinha et al. 2008)

F – Implementation: this final step corresponds to the practical application of the simulation model to test suitable policies. Two types of implementation may occur as a result of a simulation study: this study can either be translated into a tangible product, i.e. into a clear recommendation on some action or actions that should or should not be taken; or it might be used to improve knowledge and insights about the system (Pidd 2004).

4.2. Proposed simulation models

Throughout the process of developing our models the previously described steps were also applied. For the problem structuring task, we initially tried not only to understand the current challenges that the Portuguese primary health care sector is now facing but also to improve our insights about the ongoing reforms that are being implemented to overcome these challenges (namely the creation and implementation of family health units). Then, during the modelling step, the conceptual models for the two existing types of primary health care units were built, implemented on Simul8 and then validated. Additionally, a new scenario was tried and the respective results analysed and discussed so that the implementation step could be applied. However, before this description, a briefly presentation of the studied region and of the analysed primary health care units is made.

4.2.1. Studied region

The chosen region to implement and test the proposed simulation model is now presented as well as the characteristics of the selected primary health care centres and FHUs that exist within the health region.

Description of the studied region

Greater Lisbon is a Portuguese NUTS III sub-region integrated in the Lisbon region. This sub-region is formed by 9 municipalities: *Amadora*, *Cascais*, *Lisboa*, *Loures*, *Mafra*, *Odivelas*, *Oeiras*, *Sintra* and *Vila France de Xira* (Figure 9).

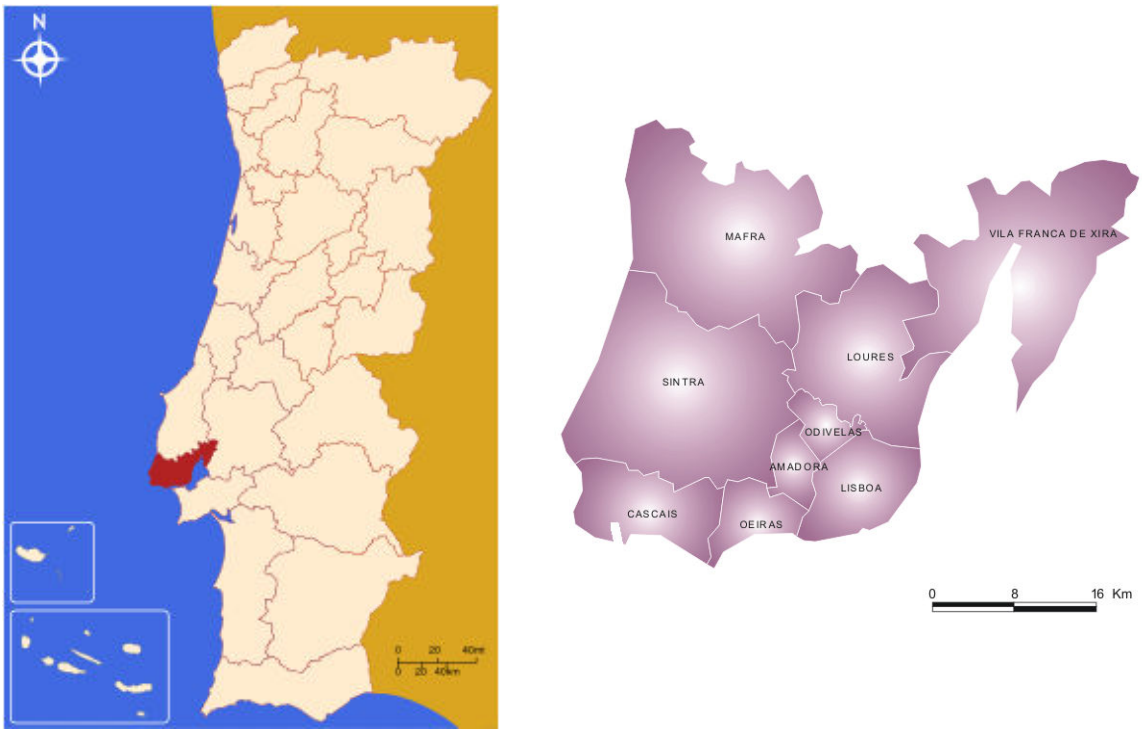


Figure 9: Left: Portuguese NUT III regions. Right: Greater Lisbon sub-region. (Ministério da Educação - Gabinete de Estatística e Planeamento da Educação)

The present work studies FHUs and PHCC from three different municipalities of the Greater Lisbon sub-region: *Lisbon*, *Oeiras* and *Cascais*. As we can observe, these three municipalities are adjacent to each other along the Tagus river.

The main reason why this set of units was selected is related with fact that the Greater Lisbon region is an urban zone with a high population density and has been characterized by a population growth above the national average during the last six years (4.02% of population growth between 2001 and 2007, against a national growth of 2.52% for the same period). This growth is mostly explained by internal migration phenomenons from populations (especially younger) moving closer to Lisbon, looking for better economic conditions (Salgueiro 2003). Thus, this high density and growth have been contributing significantly to an increasing pressure on health care demand in these sub-urban regions, which makes highly interesting and pertinent to choose them for the purpose this work. Moreover, as we can observe in figure 9, the units we choose are located along a continuous coastline that is constituted, as we will see, by populations with different characteristics and consequently with different health care needs (e.g. different demand for consultations). Thus, our system is more heterogeneous and general. Other reasons are related with the fact the these health care units were the ones with a higher amount of data available and that were closer, allowing us to gather that information easier by means of some personal interviews.

Regarding the data about the municipalities where the primary health care units we chose are located (Table 1 and Table 2) it is possible to observe that these populations have different demographic characteristics. In Lisbon, it is clear that not only the number of inhabitants decreased, but also the associated ageing index is high. The further we move out from Lisbon, the more significant is the increase on the number of inhabitants and the lower is the ageing index. This proves that there is a migration phenomenon of the younger population leaving the centre and settling in the outer areas of Lisbon (Salgueiro 2003).

Region	Population 2001	Population 2007	Variation (%)	Ageing Index
Greater Lisbon	1 947 261	2.025.628	4,02	109,9
Lisboa	564 657	499.700	-11,50	177
Benfica	41 368	-	-	-
Carnide	18 989	-	-	-
São Domingos de Benfica	33 678	-	-	-
Oeiras	162 128	171.472	5,76	113,8
Barcarena	11 847	-	-	-
Carnaxide	21 354	-	-	-
Oeiras e São Julião da Barra	34 851	-	-	-
Paço de Arcos	23 496	-	-	-
Algés	19 542	-	-	-
Cruz Quebrada-Dafundo	6 591	-	-	-
Linda-a-Velha	21 952	-	-	-
Cascais	170 683	186.947	9,53	99,2
Alcabideche	31 801	-	-	-
Cascais	33 255	-	-	-
Estoril	23 769	-	-	-

Table 1: Evolution of the population in the three studied municipalities from 2001 (Instituto Nacional de Estatística 2001) and 2007 (Instituto Nacional de Estatística 2007) and the correspondent ageing index

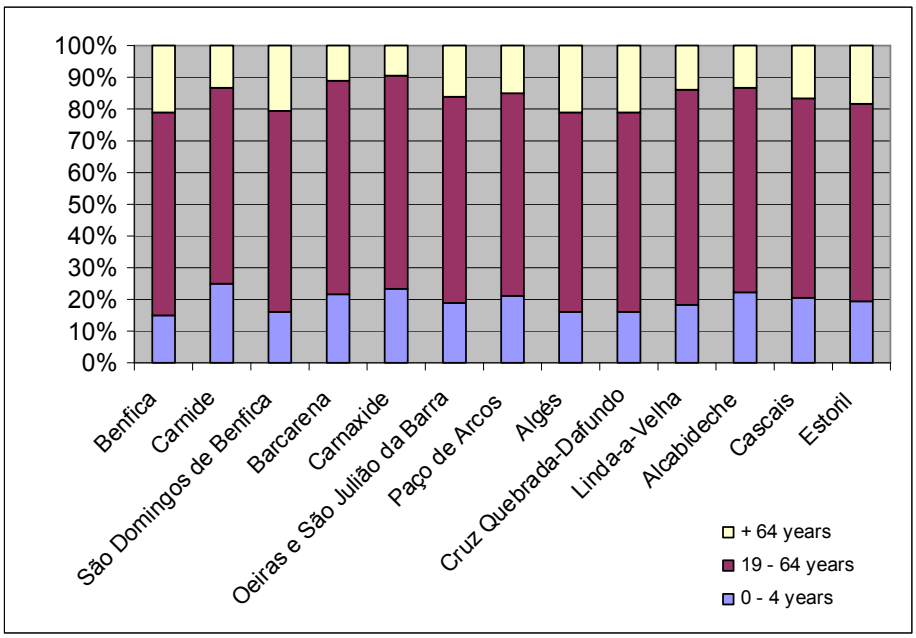


Table 2: Distribution of the ages for 2007 inside the municipalities studied. (Instituto Nacional de Estatística 2005)

Primary health care units in the studied region

We have selected nineteen primary health care units in our study: twelve primary health care centres (PHCCs) and seven family health units (FHUs). In the following table, all these primary health care units are listed with the correspondent's civil parishes and with the catchment population (population reached).

Municipality	Civil Parishes	Primary Health Care Unit	Population Reached
Lisboa	Benfica	PHCC Benfica	27478
		PHCC Marchal Carmona	40440
		FHU Rodrigues Migueis	10770
	Carnide	FHU Carnide	11258
	São Domingos de Benfica	PHCC Sete Rios	75336
		FHU Tílias	11000
Oeiras	Carnaxide	PHCC Linda-a-Velha	61747
		PHCC Algés	38549
		FHU Dafundo	11300
	Oeiras	PHCC Oeiras	47426
		PHCC Paço de Arcos	40252
		PHCC Barcarena	12375
		FHU Delta	14800
		FHU São Julião	14625
Cascais	Cascais	PHCC Cascais	43435
		PHCC Estoril	34776
		PHCC Alvide	19568
		PHCC Alcabideche	17305
		FHU Marginal	14800

Table 3: List of the studied primary health care units and population reached (Instituto Nacional de Estatística 2007)

It is important to refer that our models were applied to the presented health care units (Table 3) and, as we will later observe, these models were built using information regarding these units' human and physical resources.

4.2.2. Description of the conceptual model

As we previously showed up, population's characteristics and needs might vary substantially among the several regions. Due to this heterogeneity and diversity, primary health care units (PHCCs and FHUs) have to make specific adjustments on their operational management to answer to health care needs of their populations. These particular adjustments might be for example a specific timetable for each healthcare unit or a particular schedule for each physician. Being too complex and both time and resource consuming to model and implement all these particular specifications, an attempt was made to work with the most general model for each type of primary health care unit. This way, two generic conceptual models are proposed: one for a PHCC and one for a FHU. Each of these models was respectively applied to every PHCC and FHU selected on the case study and presented in Table 3. We present now the conceptual models for PHCC and for FHU.

Conceptual Model of a primary health care centre (PHCC)

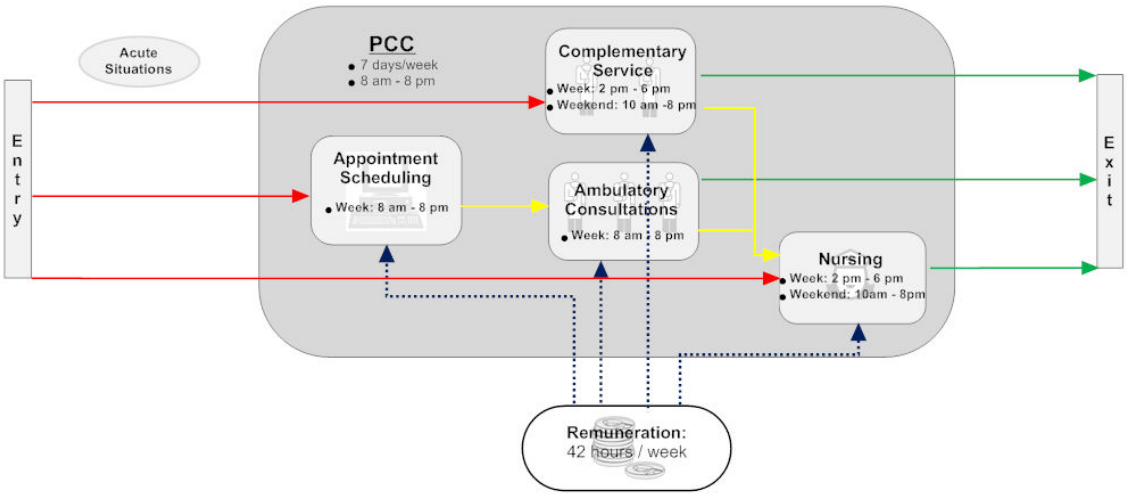


Figure 10: Conceptual model of a primary health care centre

The above scheme represents a general diagram of the model of a primary health care centre. The four involved processes are shown by four different colours of arrows: red, yellow, green and blue.

The red arrows represent the patient entering in the primary health care centre (the initial contact). Patients might enter the PHCC virtually for scheduling an appointment with the correspondent GP, or physically for attending a consultation with a specific GP for a particular day and hour, or to access the Complementary Service (urgent service) in an acute/urgent situation or directly for a nursing consultation (usually without being previously set up).

The yellow arrows represent the internal flow of patients inside the primary health care centre. This internal flow may occur in several different ways: after entering the PHCC with a previously

set up consultation, patients might be directed to the physician's cabinet, on the appointed day and hour, for their consultation; patients may also enter the primary care centre, and through a first in first out system, are taken care of in the nursing care unit; finally, there can also be a flux of patients that after attending the Complementary Service or having a consultation with the physician require nursing care, being directed to that unit. Several other types of consultations could have been included in our models. Either because no sufficient data was gathered or because they were not quantitatively significant, house calls and other specialized type of consultations (e.g. oncology, women's health, etc) were not considered in our models.

The green arrows describe the exiting of patients from the primary health care centre. It can occur after the consultation with the GP, after nursing care or directly after the Complementary Service.

Finally, we have the blue arrows representing the model's type of remuneration. The most common form of payment in primary health care centres is still the salary. Thus, in these units, the majority of personnel's remuneration is ruled by the 42 hours/week public administration's legislation for the correspondent sector and career (Gouveia et al. 2007a).

Conceptual model of a family health unit (FHU)

The next scheme represents a general diagram of the conceptual model of a family health unit (FHU). As it was previously said, these family health units are constituted by multi-professional teams, formed by general practitioners, nurses and managers and have an innovative model of incitement to all these FHU professionals, rewarding the individual and collective performance. Moreover, differently to primary health care centres, there is not a specific and independent unit for acute/urgent cases.

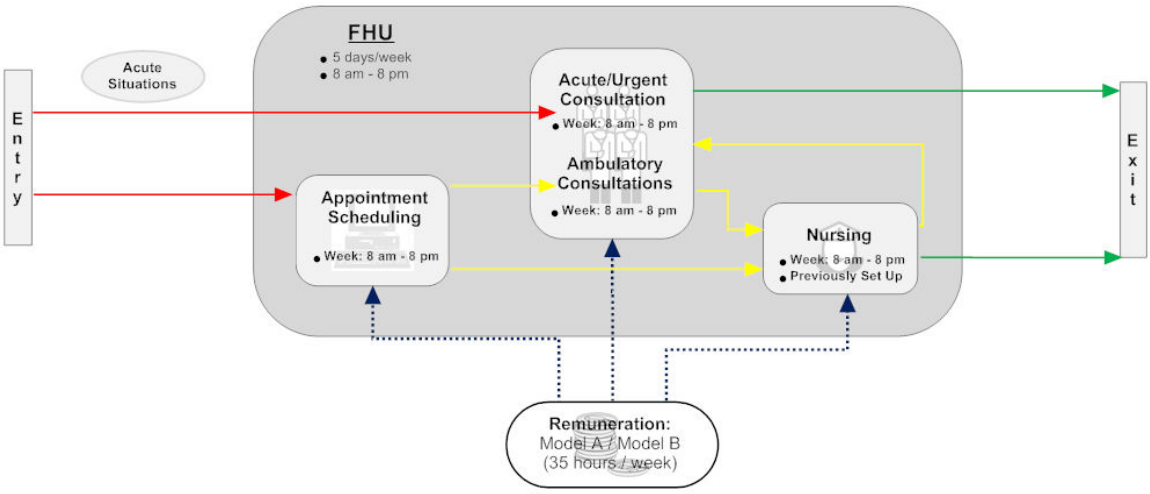


Figure 11: Conceptual model of family health unit

Like the model for PHCC, the four involved stages are shown by four different colours of arrows and again reds represent the entry flow, yellow ones describe internal flux of patients, green arrows the exit of these same patients from the FHU and blue the remuneration type.

Again, the red arrows represent the patient entering in the primary health care centre (the initial contact). Patients might enter the PHCC virtually for scheduling an appointment for the GP or for nursing, or physically for attending a consultation with a specific GP or nurse for a particular day and hour, or to access the Urgent/Day Consultation.

Nevertheless, the treatment of emergency/day consultations in FHUs very much differs from the one in PHCCs. There is a multidisciplinary team of GPs responsible not only of a specific list of patients but also of solving all the emergent situations. During a working day team of physicians intercalate their specific patients' list consultations with the several emergent cases that appear. If necessary they can inter-substitute between them in order to achieve better health care results and higher satisfaction to the patient.

The internal flow (yellow arrows) of patients inside the FHU can occur through several different pathways. After setting a consultation, the patient is directed to the consultation with the GP or for nursing care on the appointed day and hour. There can also be a flux of patients that after attending an emergency consultation or having an appointment with the physician need nursing care. Besides this, there is also a proportion of patients that after a nursing consultation are directed to a consultation with a GP.

The exit (green arrows) of patients from FHU can occur after the consultation with either the GP or nurse or after the emergency consultation.

Finally, we have the blue arrows representing the model's type of remuneration. In FHUs, it is usually associated a 35 hours/week remuneration (fixed component) with or without financial incentives (Model B or A, respectively).

To sum up, we have built two conceptual models for FHU and PHCC that entail organizational models that mainly differ on:

- Appointment Scheduling: In primary health care centres, it is only possible to set up a consultation for physicians. However, in a FHU, besides this last type of appointments, there is also a setting up for nursing care.
- Physician's Appointments: Both in primary care centres and in FHUs, the consultations with the GP are previously set up for a specific day and hour. However, in FHUs there are no patients without an associated physician. This means that, in a FHU, patients are taken care and treated by the same GP the majority of the times. On rare occasions,

when that does not happen, there is inter-substitution between physicians, potentially leading to higher level of production and satisfaction to the patient.

- Acute/Urgent Situations: In some primary care centres, there might exist a service for acute situations named Complementary Service. This service has its own physicians, working on predetermined shifts. This means that this service is only available in certain days and at certain time periods. On the other hand, there is the so called Urgent/Day Appointment in FHUs. It is also a service designed for acute cases. However it works in a different way – due to some gaps that exist, intentionally, in the physician appointment schedule – these acute cases can be taken care of on those gaps, with preference by the GP responsible for the patient. If the correspondent GP is not available, another GP might take care of that patient (inter-substitution). This way, as long as the FHU is opened, acute cases might be taken care of if resources are available in the FHU. Usually, FHUs do not operate during the weekends, which implies that patients under acute situations will need to access the correspondent primary health care centre or hospital.
- Nursing Care: Concerning nursing care, the most significant difference between primary care centres and FHU is the possibility on FHU to set up an appointment to a specific day and hour. In primary care centres patients are taken care of in a first in, first out logic.
- Remuneration: In primary health care centres, there is a prevalent type of remuneration method. This method is ruled by the public administration's legislation, usually corresponding to an exclusive 42 hours/week period salary. As previously explained, FHUs can be organized according to three different models: A, B or C. To each of these models, it is associated a different remuneration method. From those three, the two most used models are:
    - Model A – the personnel's remuneration is ruled by the public administration's legislation, corresponding to an exclusive 35 hours/week period.
    - Model B – the remuneration process is formed by two components: a fixed and a variable one. The fixed component corresponds to the legislated remuneration for an exclusive 35 hours/week period and the variable one corresponds to all supplements that derive from worker's performance.

  On our case study, to each primary care unit studied, it was associated the respective model of remuneration (either Model A or B).

How to transform a primary health care centre into a family health unit

The present study consists on the development of discrete event simulation models to compare the performance of two types of primary health care units: FHUs vs. PHCCs. After this comparison, we aim at testing the following scenario: what would happen in the system if all the primary health care centres would be converted into family health units? This scenario tries to

capture the possible changes in efficiency, quality and costs in the system that might result from the complete application of the current primary health care reform defined by the Ministry of Health.

The process of this conversion is now explained. First, depending on the size of primary health care centres, each of them is divided into smaller subunits (with 6 to 9 physicians, 6 to 9 nurses and in average 5 managers / receptionists). Then, in each of these smaller subunits, the Complementary Service is closed, using the physicians that work there exclusively for ambulatory consultations. This way, as it was previously explained, acute situations are taken care of during all day, as long as the FHU is opened, and usually by the respective physician. So, a higher concern that every patient is taken care of and treated by his own GP both for ambulatory consultations and in acute situations becomes a priority in the FHU. A change in the physicians', nurses' and managers' remuneration is also applied. For GPs, for example, there is a switch from a 42 hours/week schedule without incentives to a 35 hours/week schedule without incentives (Model A) or with incentives (Model B). The last change corresponds to consultations for nursing care becoming previously set up instead of having patients appearing unexpectedly in the system.

4.2.3. Computational implementation

In order to implement a simulation model, among the several available packages, the Simul8 software was chosen and used (Simul8 Corporation 2000). This is a high power but user friendly simulation package.

A Simul8 simulation model corresponds to an interaction of a number of objects and lines joining them. The main objects used in a Simul8 language are: Work Items, Work Entry Points, Storage Bins, Work Centers, Resources and Work Exit Point. The lines that join them represent the flux and relations between the objects. In order to implement these relations in our Simul8 simulation model, a Visual Logic programming language was used. Hundreds of routines (rules that are programmed to control the behaviour of each object within the system) were implemented on the referred software, ruling every single behaviour of every object. As an example, we implemented a virtual appointment scheduling process for GP's consultations so that, when a patient contacts the primary health care unit's reception, depending on the virtual availability of the correspondent physician, a consultation is set up for a specific day and hour and with a specific duration, depending on the type of consultation (e.g. an adult consultation is scheduled for 15 minutes and family planning consultations for 30 minutes). After scheduling this appointment, the vacancy for this particular day and hour becomes no longer available.

The objects used are now listed:

	***Work Items*** – corresponds to the central object in the organization being simulated. Work Items flow through the simulation, being stored in storage areas, and acted upon by work centers. (E.g. patients)
	***Work Entry Point*** – is a place where work to be done appears for the first time in the model. It is possible to have as many work entry points as necessary, each can feed work in using different statistical distributions and each can set values of labels to the work items as they enter the model. (E.g. patients entering the primary care centre)
	***Storage Bins*** – is a place where work to be done can wait until the appropriate resources or work centers are available. It is one of the fundamental objects which make up the structure of the simulation model. Work items can "expire" while in a storage bin, setting the Self Life to a specific amount of time. Storage bins also allow a prioritization option. It gives the opportunity to select a label, the value of which is used to prioritize the work items at the storage bin. (E.g. there might be patients waiting for the consultation at the waiting room, and/or patients giving up the consultation after a certain amount of waiting time)
	***Work Centers*** – is the place where the work takes place. Usually, this work takes up time and sometimes requires the availability of resources. At a work centre, a work item may be transformed in some way and then sent on to another specific object in the simulation model. (E.g. physician's cabinets or nursing rooms)
	***Resources*** – are items in the simulation model which are required at work centers in order for them work to work. Work centers can not start work until a work item is available and the specific resources are also available. Resources can be available for only part of the time a simulation is running, making use of shift patterns to describe their availability. (E.g. Physicians, Nurses and Managers)
	***Work Exit Point*** – is the place where work that is complete leaves the model. (E.g. patients leaving the primary care centre)

We will now present the computational implementation of a primary health care centre. The following scheme (Figure 12) represents a specific PHCC from our case study, with its particular data (PHCC Benfica). What it is truly important in this figure are relationships that are established (equal to all the other PHCCs that we have modelled) and not the specific number of personnel that are shown in the figure. Each primary health care unit was computationally implemented within the same relations but according to the correspondent number of receptionists, physicians and nurses.

After presenting this implemented model in Figure 12, each process built within the model is analysed and explained in detail. Theses processes are: Appointment Scheduling, Complementary Service, General Practitioner's Consultations, Nursing Care and Exiting the Primary Care Centre.

Computational implementation of one primary health care centre (PHCC)

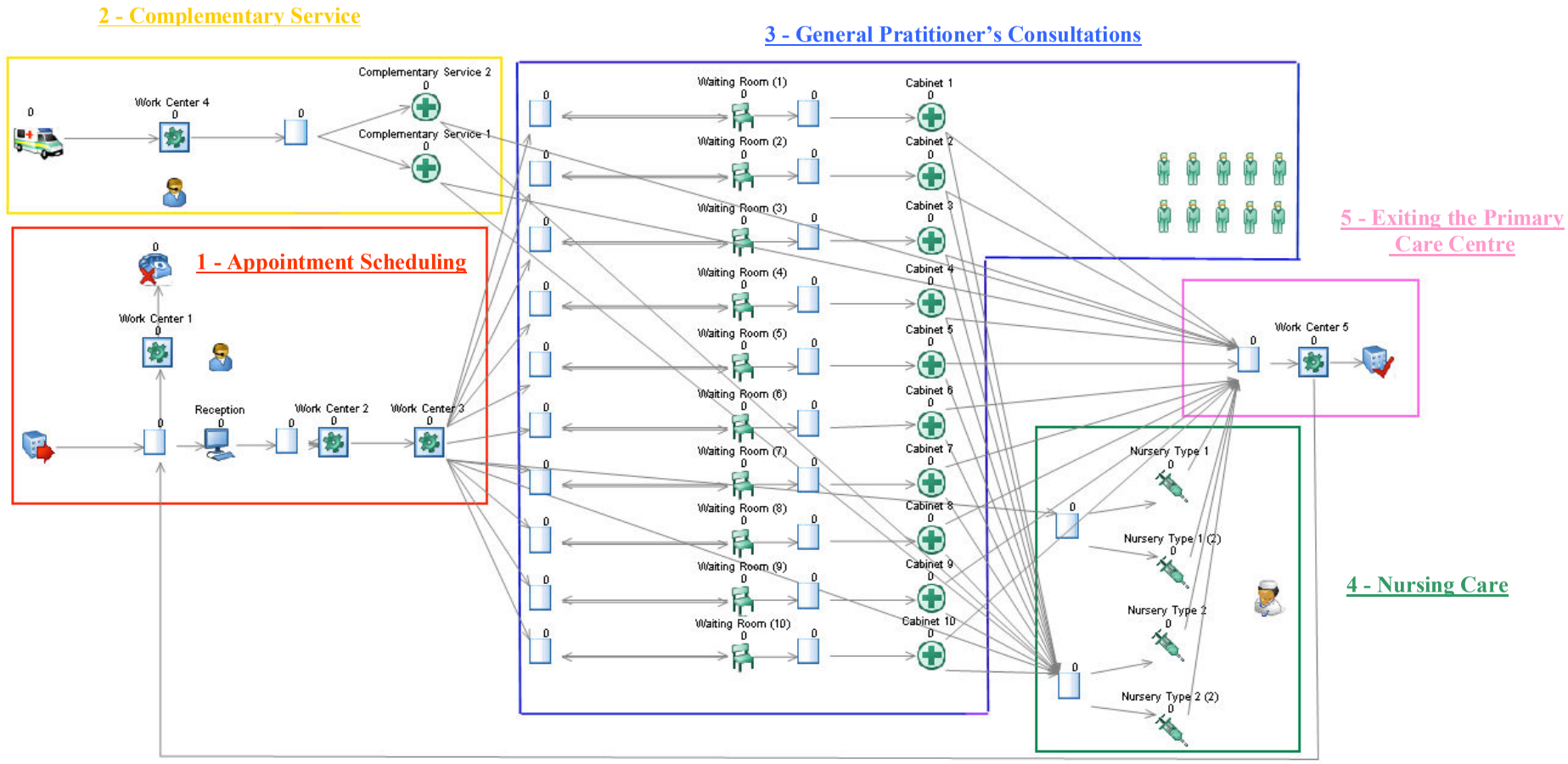


Figure 12: Computational implementation of a primary health care centre. It is important to notice that this particular figure corresponds to one specific primary health care centre from our sample. All primary health care centres studied have a similar structure, only changing the particular number of Cabinets, Physicians, Nurses[1], etc.

[1] It is important to refer that inside nursing care there are two different types of consultations:

- Type 1: Diabetes, Child or Maternal Consultation
- Type 2: Consultation for Vaccination or other type of treatments

1 - Appointment scheduling

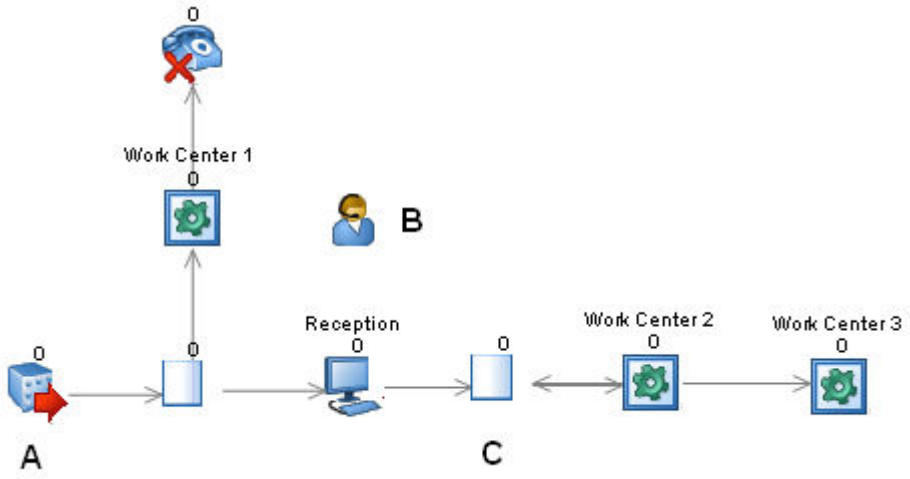


Figure 13: Appointment scheduling process in primary health care centres

In accordance to the previous figure, the first contact between the patient and the primary health care centre begins with a patient virtually calling or being directed to the reception of that same primary care centre. This first contact might occur through the Work Entry Point (**A**) and it is set by the **Inter-arrival times parameter**. Simultaneously, a certain physician and a specific type of consultation are tagged to each patient that enters, through the **Distribution Number of the GP** and **Distribution Type of Consultation**. These and the following parameters / distributions presented are described later in 4.3.4.

The next step is the contact between the patient and the receptionist directly in the primary care centre or by phone and, according to the availability of the patient and of his/her GP, setting up a consultation for a certain week, day and hour. This process is described by the **Reception** (Work Centre) which depends on the presence of the Receptionist (Resource **B)**. After this setting up, the patient is sent to a fictitious Storage Bin **C** where it stays until the appointed day of the consultation.

If a patient tries to set up a consultation but, for example, the call is not answered in a certain amount of time (e.g.10 minutes), then **Work Centre 1** sends this patient to the unanswered list of patients.

The fictitious **Work Centre 2** is responsible, through complex Visual Logic programming, of picking the right patient in the precise day of the consultation and sending it to the **Work Centre 3**.

2 - Complementary service

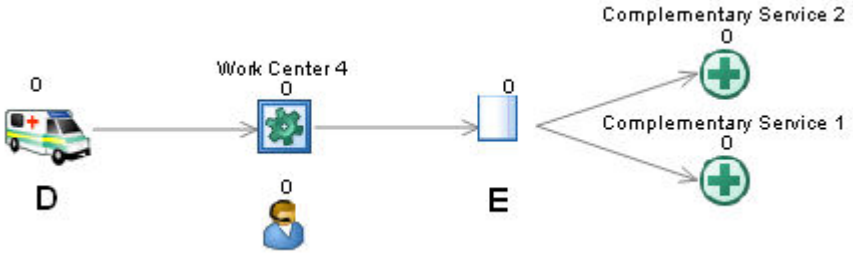


Figure 14: Complementary service process in primary health care centres

The second entry point of the primary care centre is the Complementary Service (Figure 14). The aim of this service is to respond to acute cases. Patients enter the model (through the Work Entry Point **D**) and are sent (by **Work Centre 4**) to the waiting room (**E**), where they wait to be treated and are taken care of in one of the rooms (**Complementary Service 1** or **Complementary Service 2**) by the correspondent physicians. As it was previously explained, these physicians are used in the Complementary Service and in the GP's consultation through predetermined shifts.

One important characteristic of the Complementary Service is the restricted time period in which is open. In other words, this service it is only available on some certain days, on some certain hours. In order to implement this situation, a specific shift was attached to the **Work Centre 4**, restricting patients to enter this Complementary Service only to certain time periods.

3 - General practitioner's consultations

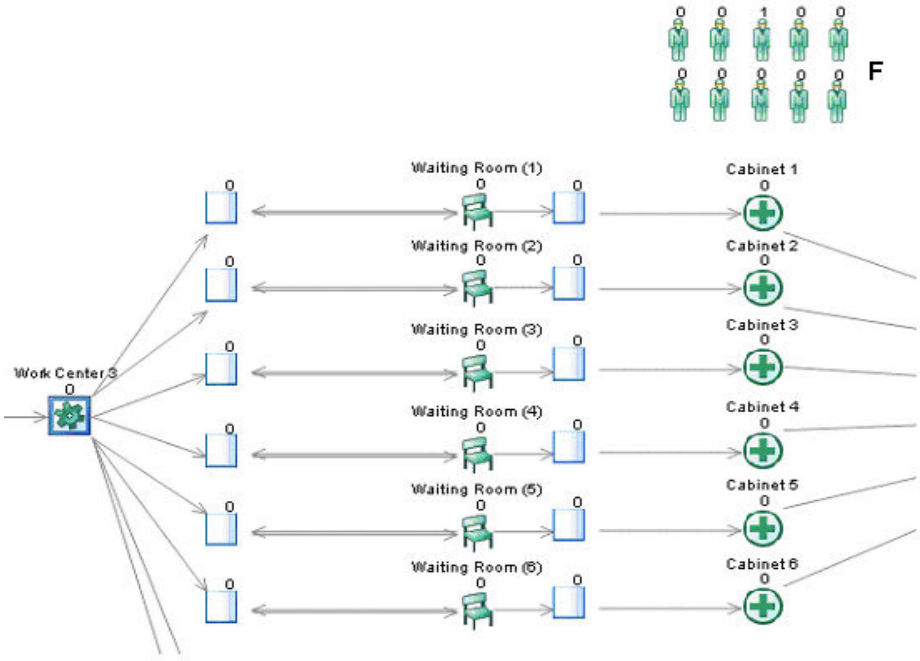


Figure 15: General practitioner's consultation process in primary health care centres

As previously stated, in the appointed day and hour, patients are guided (through Work Centre 3) to the correspondent general practitioner or Nursing room were they wait and queue for their turn (described by the **Waiting Room** and **Storage Bins**). Usually this waiting time is extended beyond the hour set up and the model records it through the parameter **Queuing Time for the Consultation**.

As soon as it is possible, the patient is called and enters the physician's cabinet (designed in the model as **Cabinet 1 to 6** in this case). The duration of the consultation is then set from two possible probability distributions. If it is an Adult Consultation, then its duration depends on the parameter **Distribution of Adult Consultation's Duration**. If it is any other type of consultation (Child, Maternal or Family Planning Consultation) this duration depends on the parameter **Distribution of Other Consultation's Duration**.

In order that all these Cabinets operate, an essential resource is needed – General Practitioners (**F**). In the simulation model these resources were organized so that some specific GPs were exclusively responsible for the previously appointed consultations and the other GPs exclusively responsible for the Complementary Service consultations.

Finally, the routing out process from the several **Cabinets** can occur in two ways. The patients can either be directed to the nursing care room or can leave the primary care centre (Work Exit Point), depending on whether they need to be taken care of by nurses or not. All this process is described in Figure 15.

4 - Nursing care

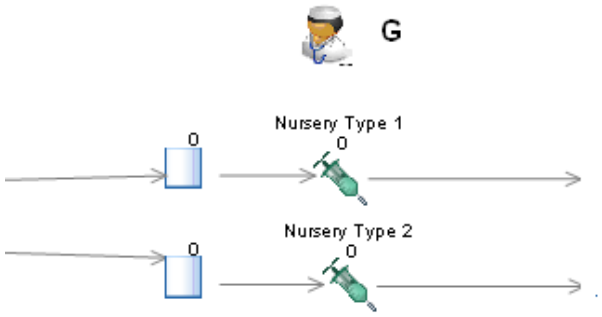


Figure 16: Nursing care process in primary health care centres

Patients may be directed to nursing care from three different sources: from GP's consultation, from Complementary Service or entering the primary care centre and waiting, without any previously set up, for nursing care service. All these patients are taken care of in a first in first out sequence (Figure 16).

As it was previously referred, there are two types of nursing consultations: type 1(Diabetes, Child or Maternal Consultation) or type 2 (Consultation for Vaccination or other type of treatments). The type of these consultations determines not only the specific nursing care room the patient is directed to but also the duration of the consultation (through the parameter **Distribution of Nursing's Type 1 Duration** or parameter **Distribution of Nursing's Type 2 Duration**). Both of these types of Work Centers depend on the presence of specific resources (Nurses – **G**), which are also driven by a specific shift schedule.

Finally, after the consultation all patients leave the primary care centre (Work Exit Point).

5 - Exiting the primary health care centre

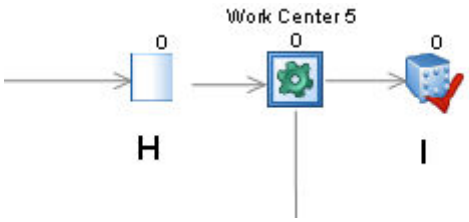


Figure 17: Exiting the primary health care centre process in primary health care centres

The process of exiting the primary care centre (Figure 17) is quite simple. All patients flow into the same fictitious Storage Bin (**H**) and **Work Centre 5**. On this work centre, a small percentage is immediately directed to the appointment scheduling process, describing those patients that set the following consultation right after exiting from a previous consultation. All the other patients (the majority) exit the model through the Work Exit Point (**I**).

The main routines (set of programmed instructions that rule our models' objects behaviour) implemented were: the process of scheduling a patient's appointment for the respective GP, for an available day and hour; the process of, on the right day and hour, close to the appointment's hour, virtually bringing patients to the waiting room for the correspondent consultation; and the setting of shifts for each professional within the FHU (physicians, nurses and managers/receptionists).

We now present the implemented model for a FHU (specifically FHU Rodrigues Migueis).

- Computational implementation of a family health unit (FHU)

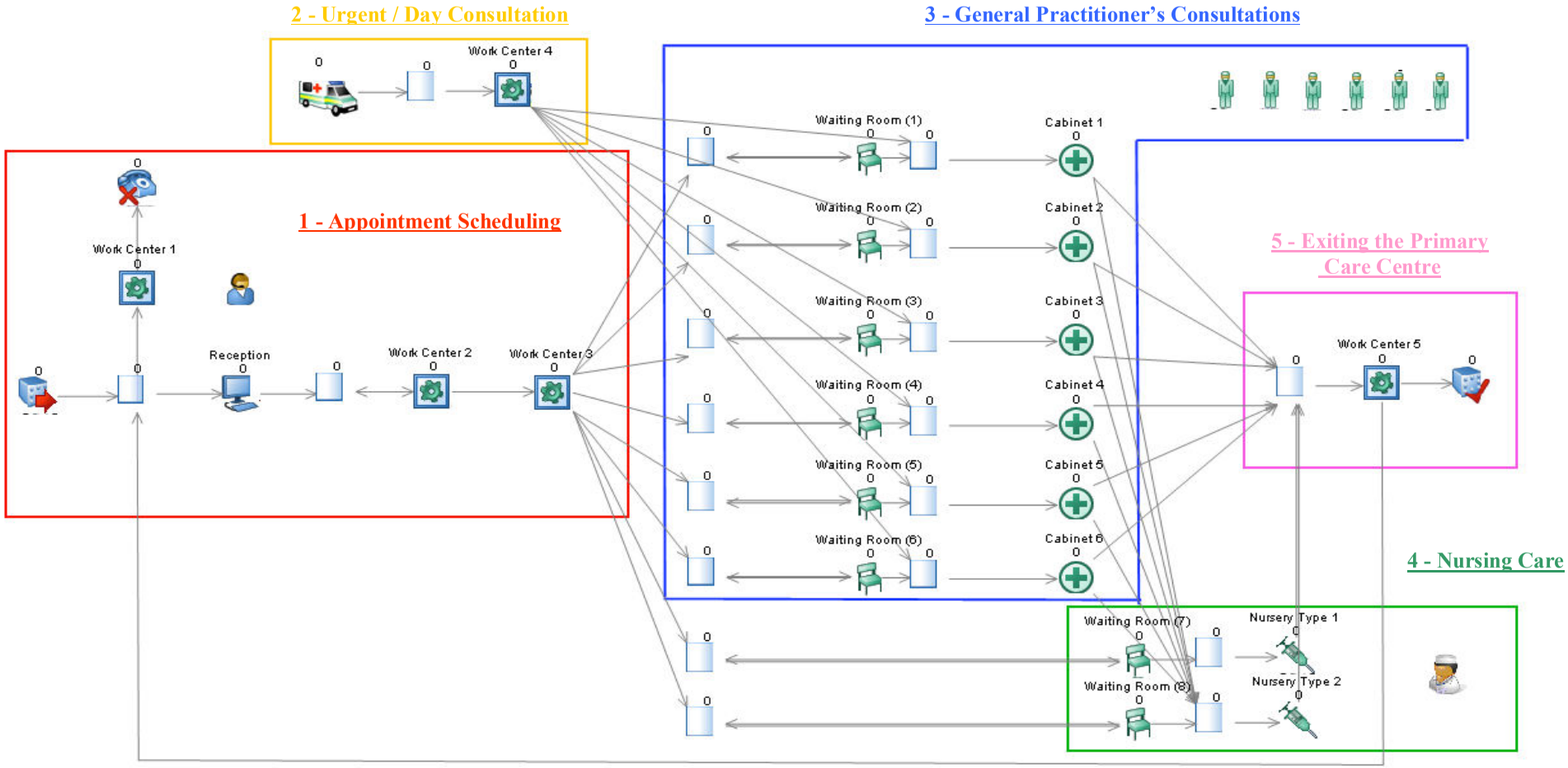


Figure 18: Computational implementation of a Family Health Unit. It is important to notice that this particular figure corresponds to one of the studied FHU. However, all FHUs studied have a similar structure, only changing the particular number of Cabinets, Physicians, Nurses[2], etc.

[2] It is important to refer that inside nursing care there are two different types of consultations:
- Type 1: Diabetes, Child or Maternal Consultation
- Type 2: Consultation for Vaccination or other type of treatments

1 - Appointment scheduling

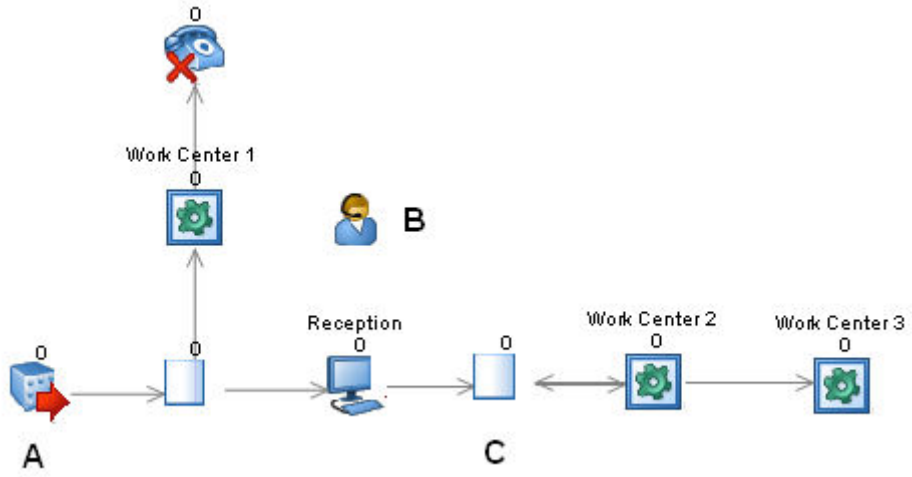


Figure 19: Appointment scheduling process in FHU

The first contact between the patient and the family health unit is initially processed in a similar way as in a primary health care centre (Figure 19). The time between new arrivals is set by the **Inter-arrival times parameter** and again, a certain physician and a specific type of consultation is associated to each patient that enters, through the parameters **Distribution Number of the GP** and **Distribution Type of Consultation**.

The next step consists of setting up a consultation, directly in the primary care centre, or by phone, and essential resources like the Receptionist (**B**) are needed in this step. This process takes place in the **Reception**. However in family health units consultations can be set up not only for the GP but also for Nursing Care. According to the availability of the patient and of his/her GP or nurse, a consultation is set up for a certain week, day and hour. Again, after this setting up, the patient is sent to a fictitious Storage Bin **C** where it stays until the appointed day for the consultation.

2 - Urgent / Day consultation

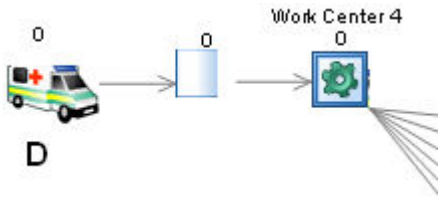


Figure 20: Urgent / Day consultation process in FHU

Figure 20 represents the second entry point in a Family Health Unit. In FHU, acute cases are taken care of and treated in the moment, with preference, by the correspondent GP (patients are registered to a single GP). If the correspondent GP is not available, then another GP from

the same FHU will take care of the patient (inter-substitution if there is a GP not busy). Entering the model through the Work Entry Point **D**, the patients are then directed (through Work Centre 4) to the correspondent physician's cabinet queue with high priority.

This Day Consultation works every day of the week simultaneously with the other resources of the FHU, i.e. it is available from the moment that the FHU opens until it closes. This enables acute cases to be taken care of anytime, as long as the FHU is open and there are available resources.

3 - General practitioner's consultations

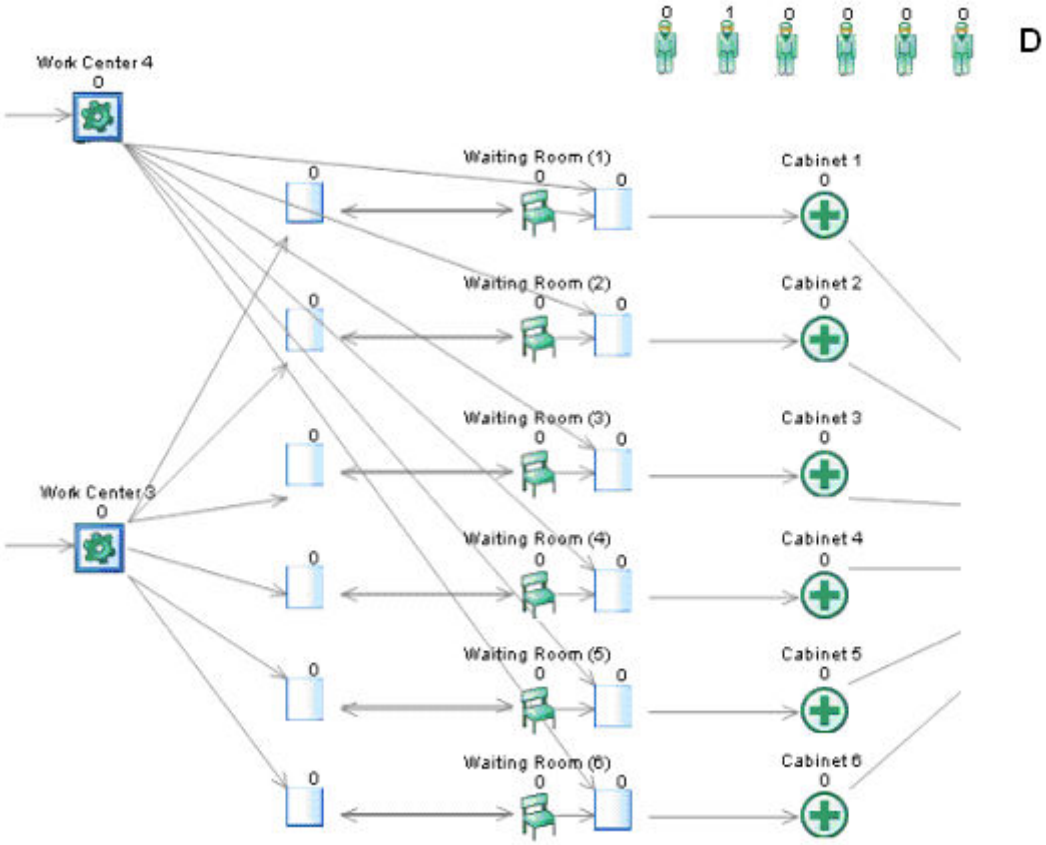


Figure 21: General practitioner's consultation process in FHU

As it was previously explained, there are two possible routes leading the patients to GP's consultations. The need for a consultation may have origin in acute situations (Work Centre 4) or in previously set up consultations (Work Centre 3). Patients from this last source make their way to the FHU, in a certain day and hour, for one of these types of consultations: Adult, Child, Maternal or Family Planning. This routing is performed in the model through Visual Logic (VL) programming in Work Centers 3 and 4.

Before being taken care of by the physician, these patients usually wait a certain amount of time in the **Waiting Room**. This waiting time is recorded through the parameter **Queuing Time for the Consultation**. It is important to notice that usually, acute situations have higher priority over these patients.

Similarly to the primary health care centres, the duration of the consultation depends on the type of consultation. If it is an Adult Consultation then its duration depends on the parameter **Distribution of Adult Consultation's Duration**. If it is Child, Maternal or Family Planning consultation it depends on the parameter **Distribution of Other Consultation's Duration**.

Concerning the **Cabinets**, for them to work, an essential Resource is needed – General Practitioners (**D**). They are responsible for taking care of patients not only with a previously set up consultation but also with an emergent situation.

Finally, and similarly to the primary health care centres, the routing out process from the several physician's **Cabinets** can occur in two ways. The patients can either be directed to the exit of the FHU (Work Exit Point) or to the Nursing Care room depending on the percentage discipline defined. All this process is described in the Figure 21.

4 - Nursing care

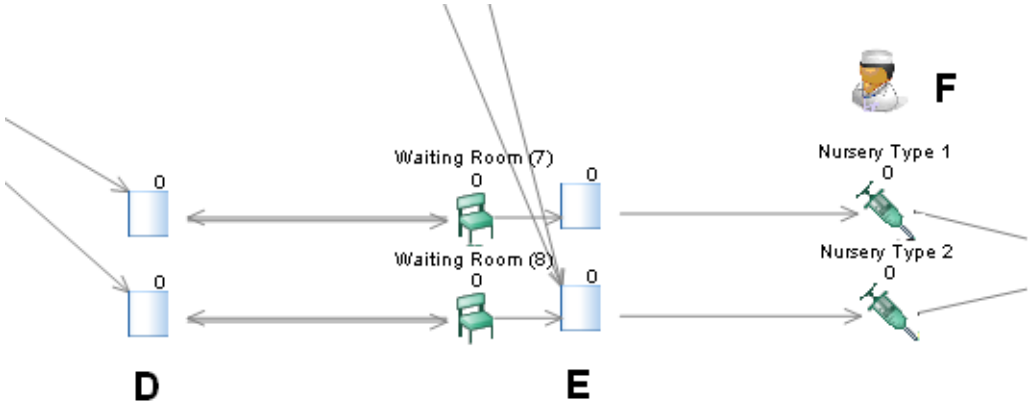


Figure 22: Nursing care process in FHU

In Family Health Units, patients may be directed to Nursing Care from two possible sources: right after the consultation with the GP or after setting up a specific Nursing consultation. This last option constitutes an innovation around primary health care units and was created with the aim of relieving of congestion the waiting rooms and to improve the efficiency of this service

As we can observe in the Figure 22, patients with a previously set up consultation for nursing are directed to an auxiliary Storage Bin **D** were they stay until the appointed day and hour for

the consultation. On that day and hour, they are sent to the queue for Nursing room (**E**). Patients directed from the GP's cabinet are also sent to this queue, where they also wait for being taken care of at the Nursing's room.

As it was explained before, there are two types of nursing care consultations: type 1 and type 2. The duration of the consultation (defined by the parameters **Distribution of Nursing's Type 1 Duration** or **Distribution of Nursing's Type 2 Duration**) and the Nursing Care room the patient is directed to depend on the type of nursing consultation (type 1 or type 2). These consultations require the presence of specific resources - Nurses (**F**) - which are also driven by a specific shift schedule.

After the consultation all patients are directed to the exit of the Family Health Unit (Work Exit Point).

5 - Exiting the family health care units

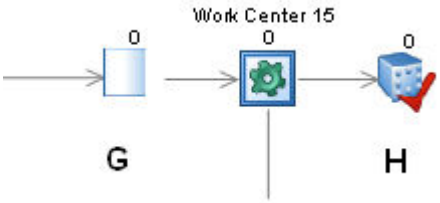


Figure 23: Exiting FHU process

The process of exiting the Family Health Unit (Figure 23) is quite similar to process observed in the primary care centre. All patients flow into the same fictitious Storage Bin (**G**) and **Work Centre 15**. Through this last work centre, a small percentage of work items is immediately directed to the appointment scheduling process, describing those patients that set up the following consultation right after exiting from one consultation. On FHU this percentage is significantly lower as there is no need of scheduling the appointments with such antecedent. The majority of patients exit the model through the Work Exit Point (**H**). It represents the final contact between the patient and the FHU.

The main routines (set of programmed instructions that rule our models' objects behaviour) implemented were: the process of scheduling a patient's appointment for the respective GP or nursing care, for an available day and hour; the process of, on the right day and hour close to the appointment's hour, virtually bringing patients to the waiting room for the correspondent consultation; the process how acute patients and their high priority is managed when they enter the FHU; finally, the last main routine implemented regards the setting of shifts for each professional within the FHU (physicians, nurses and managers/receptionists).

4.2.4. Application to the case study (model's variables, parameters, distributions and assumptions)

In this subsection, the variables, parameters, KPIs and distributions used on our models are described. Moreover, we explain the assumptions made during their implementation.

In order to take the maximum advantage of the simulation models' potentialities, a set of variables is implemented. These variables correspond to values that are calculated within the model allowing us to extract additional information from it. For example, we implemented a variable that returns the precise moment when a patient enters the waiting room and another one that returns the precise moment that this same patient enters the cabinet for the consultation. This way, using the previous two variables it is possible to define a third one regarding the total amount of time this patient had to wait on the waiting room.

List of variables computed in the model:

	Variable	Comments
Entry	Time of Entry	Corresponds to the moment when the patient enters the health care unit. It is the time passed since the model started running
Internal Flow	Consultation_Week	Week for which the consultation is set up for
	Consultation_Day	Day of the week that the consultation is set up for
	Consultation_Hour	Hour of the day that the consultation is set up for
	Consultation_Minutes	Minutes that the consultation is set up for
	Number of Waiting Days for the Consultation	Corresponds to the number of days a patient has to wait in order to have a consultation with the correspondent physician. It is calculated subtracting the Time of Entry to the date set up for the consultation
	Number of Adult Consultations	-
	Number of Child Consultations	-
	Number of Maternal Consultations	-
	Number of Family Planning Consultations	-
	Number of Nursing Type 1 Consultations	-
	Number of Acute/Urgent Consultations	-
	Number of Nursing Type 2 Consultations	-
	Waiting time to see the Receptionist	Amount of time that a patient waits in the queue of the reception
	Queuing Time for Consultation	Amount of time that a patient stays in the waiting room before the appointed consultation
	Acute/Urgent Waiting Time	Amount of time that a patient stays in the waiting room before an accessing an acute/urgent consultation
	Percentage of use of Receptionists	-
	Percentage of use of Physicians	-
	Percentage of use of Nurses	-
	Costs with Personnel	-
	Costs with diagnosis tests and other treatments	-
	Total Costs	Is equal to the sum of the Personnel Costs with the Costs related with diagnostic tests and other treatments

Table 4: List of the variables used in the model

List of parameters:

The list of parameters used in order to correctly calibrate the models is now presented. Additionally, the correspondent values and sources of information used are also presented.

	Parameter	Properties	Value	Source of information
Entry	Inter-arrival time	Time between new arrivals at the primary health care unit. It was set for each organization from the correspondent data about the total number of consultations, number of working days and timetable	Average Distribution	▪ Statistics 2006 (Administração Regional de Saúde Lisboa e Vale do Tejo - 2007) ▪ Activity Reports and Action Plans of each health care unit (USF Dafundo 2008; USF Delta 2008; USF Marginal 2008; USF Rodrigues Migueis 2008; USF Tílias 2008) ▪ Direct contact and interviews to several health care unit ▪ Cuidados de Saúde Primários - Actividade 2004 (Administração Regional de Saúde Lisboa e Vale do Tejo - 2005)
	Distribution Type of Consultation	It is a parameter that attributes to each patient one of the possible types of consultations: Adult, Child, Maternal or Family Planning Consultation.	Probability Profile	
	Distribution Number of the GP	Parameter that associates to each patient that enters the model, a certain general practitioner (represented by a number)	Probability Profile	
Internal Flow	Distribution Days for the Consultation	Number of days a patient has to wait in order to have a consultation	Normal Distributions	
	Doctor's Schedule	Number of hours per week doctors dedicate to consultations and the respective distribution during the week	-	
	Nurse's Schedule	Number of hours per week nurses dedicate to consultations and the respective distribution during the week	-	
	Distribution of Adult Consultation's Duration	Duration (in minutes) of an Adult consultation with the physician	Log Normal Distribution	
	Distribution of Other Consultation's Duration	Duration (in minutes) of another type of consultation for physicians (Child, Maternal or Family Planning Consultation)	Log Normal Distribution	
	Distribution of Nursing's Type 1 Duration	Duration (in minutes) of a type 1 nursing consultation (Diabetes, Child or Maternal Consultation)	Average Distribution	
	Distribution of Nursing's Type 2 Duration	Duration (in minutes) of a type 2 nursing consultation (Vaccination or other types of simple treatments)	Average Distribution	
	Cost per consultation with personnel	Cost per consultation regarding personnel expenses (physicians, nurses and managers)	PHCCS (13,25€) FHUs (16,32€)	(Gouveia et al. 2007a)
	Cost per consultation with diagnosis tests and other treatments	Cost per consultation regarding expenses with drugs, complementary diagnosis tests and other treatments	PHCCS (39,20€) FHUs (29,20€)	(Gouveia et al. 2007a)

Table 5: List of the parameters used in the model

Key Performance Indicators

Key Performance Indicators, also known as KPIs, help an organization to define and measure progress towards organizational goals (Reh 2007). They are quantifiable measurements that reflect the critical success factors of an organization. However, when defining them, it is critical to limit their selection to those that are truly essential to the organization in order to keep everyone's attention focused on achieving them.

Once good KPIs are defined, it is possible to use them as a performance management tool, giving everyone in the organization a clear picture of what is important and of what they need to make happen. Studies prove that posting these KPIs in the organization, showing their respective target and progress, contributes for motivating workers to reach them (Reh 2007).

In order to compare both the FHU and the PHCC models, we have chosen a set of indicators for comparison, as defined in Table 6. These indicators might be seen as relevant KPIs that could be implement within these primary health care units' information system.

	Indicator	Type of indicator
Appointment Scheduling	Average waiting time to see the Receptionist (min.)	Efficiency and Quality
	Average number of days for a consultation with the physician (days)	Efficiency and Quality
	Average percentage of use of Receptionists (%)	Efficiency
General Practitioner's Consultations	Average number of Consultations per Physician	Efficiency
	Average time spent in the waiting room (min.)	Efficiency and Quality
	Average percentage of use of Physicians (%)	Efficiency
Acute/ Urgent Consultations	Average number of acute/urgent consultations per physician	Efficiency
	Average waiting time for an acute/urgent consultation (min.)	Efficiency and Quality
Nursing Consultations	Average number of nursing consultations per nurse	Efficiency
	Average time spent in the waiting room for diabetes, child or maternal consultations (type 1) (min.)	Efficiency and Quality
	Average time spent in the waiting room for vaccinations or other types of treatments (type 2) (min.)	Efficiency and Quality
	Average percentage of use of Nurses (%)	Efficiency
Costs	Average total costs (€)	Costs
	Average costs with Personnel (€)	Costs
	Average costs with diagnosis tests and other treatments (€)	Costs

Table 6: List of the key performance indicators used in the model

Distributions

As it was explained in subsection 4.1.4, the present work is based on discrete-event simulation models (DES). One of the properties of this type of models is their non deterministic (stochastic) character, meaning that the parameters are described by a probability distribution which captures uncertainty.

Several types of probability distributions were tried so that each of them could fit the best to a specific parameter. The process of calibrating each of these distributions is a fundamental step that is critical in the construction and validation of the model. Inserting the available data for each parameter on the Expert Fit Software (Law 2006), the program will automatically suggest which probability distribution best represents our data, from a set of seven possible continuous distributions (exponential, gamma, log-logistic, lognormal, normal, uniform, and Weibull) and five discrete distributions (binomial, geometric, negative binomial, Poisson, and uniform) (Law 2006). This ExpertFit software is extensively used by analysts performing discrete event simulation studies of real-world systems in application areas such as manufacturing, military planning, transportation, healthcare and communications networks (Law 2006).

In the next table (Table 7), we present the probability distributions chosen after the calibration of distributions process. The properties of each of these distributions (average and standard deviations) were adapted specifically for each model, i.e. each model has its specifics properties of average and standard deviation. Thus, only the properties that are common between all the models are specified in the table.

Probability Distributions	Parameter	Common Properties
Average	Inter-arrival's times	-
	Type 1 Nursing Consultation's Duration	-
	Type 2 Nursing Consultation's Duration	-
Normal	Days for the Consultation.	Average: 15 days ; Std Dev: 10 days
Log Normal	Adult Consultation's Duration	Average: 15 min ; Std Dev: 10 min
	Other Consultation's Duration	Average: 30 min ; Std Dev: 10 min
Probability Profile	Number of the GP	-
	Type of Consultation	-

Table 7: List of the distributions used for each parameter

It is important to refer that the Probability Profile distribution belongs to a particular type of distributions available in the Simul8 software, where the user is able to generate the shape of distribution desired. More information about the distributions used can be found in (Hauge et al. 2004; Wolfram Mathematica 2006).

Assumptions

We present here a summary of key assumptions used in the developed models. Knowledge about these assumptions is important to understand the model and to interpret results.

▪ In primary health care centres, physicians' schedule is usually set for 42 hours/week. However, not all these hours are specified for ambulatory or emergent consultations. There is a certain amount of hours allocated for "non-assistance tasks", i.e. for administrative and/or management tasks. Despite this period changes among physicians and among the several primary health care centres, it corresponds to an average of 5/6 hours/week per physician. Additionally, there are the house calls (1 or 2 hours/week per physician) which were not taken into account too. So, not considering these two types of activities, the effective number of hours per week and per physician is between 35 and 40. This was the interval used to define the number of hours a physician works in a primary health care centre. ▪ In Family Health Units, the physician's schedule is usually set for 35 hours/week. And a major percentage of these 35 hours is assigned for Adult, Child, Maternal or Family Planning consultations. However, there might be some time reserved for certain specific types of consultations like Oncology or house calls. Despite their importance, they represent a small percentage of the total number of consultations and the number of extra routines and parameters that would have to be defined plus the lack of information about them made us to choose not to take them into account. Moreover, oppositely to primary health care centres, in FHUs there are no "non-assistance" hours. Thus, an average of 35 hours/week was defined for physicians in FHUs.
▪ Either in primary health care centres and FHUs, a schedule was created for each physician so that consultations could be previously set up. When the patient arrives to the reception for setting up a consultation, the variable Days for the Consultation is generated from a normal distribution with specific values for each health care unit. However, this specific type of information was very difficult to gather, leading us, for some occasions, to use information of one similar health care unit to define the other.
▪ In both models, the results collection period, i.e. the amount of time that the simulator runs while collecting results was set to 50 weeks, which corresponds to 250 working days. Holidays were not taken into account.
▪ Three of the seven FHUs studied were only created on the beginning of the second semester of 2007. This way, a conversion of the number of consultations for one semester was converted into an entire year, in a directly proportional way.
▪ In order to study the costs, the hypothesis that FHUs have the same costs has the Experimental Remuneration Regimen operating in 2005 was used (Gouveia et al. 2007b).
▪ Due to the lack of information about the number of receptionists/administratives working in primary health care units, a sufficient number was used so that the waiting times in the reception would be acceptable (nevertheless one should take into account this when analysing the results).

4.3. Validation of the proposed model

As defined earlier in this chapter, validation is the process of determining whether a simulation model is an accurate representation of the system, for the particular objectives of the study (Fishman & Kiviat 1968). The ease or difficulty of this validation process depends on the complexity of the system being modelled. Moreover, it is required a clear notion that the model can only be used in certain circumstances. Thus, under these conditions, if a simulation model is considered "valid", then it can be used to make decisions about the real system (Law 2000).

The goal of the present work is to compare the performance of primary health care centres and family health units using the previously listed KPIs, in order to evaluate the impact of the latest primary health care reforms in Portugal. This way, in order to validate the developed model, a comparison approach between the available information of the real system and the output of the proposed models was made. This methodology is called a black-box testing. We describe here the process and the results from validation.

The process of validating and calibrating of the model is divided in two parts. Initially, in order to queues (and other aspects in the simulation) get into the typical conditions of running in the real system, a warm-up period must be used. It corresponds to the time that the simulation will run before we start collecting results. After some research and several attempts, a warm-up period of 52 weeks (one year) was set. The reason for this value is because, after one year, parameters like queues and waiting times were stable, i.e. they approached a certain value. The second part is the setting of the collection period. It represents the amount of time each model is run before it returns the results (in the present work we set it to one working year - 50 weeks).

As it was said before, each of the three studied municipalities (*Lisbon*, *Oeiras*, *Cascais*), is formed by several PHCCs and FHUs. A model of each one of these health care providers was built and run separately using a trial of five runs (generating different random numbers). In this way, for each run of the model a set of results are produced (varying with the stochastic elements of the model). With these values, we were able to obtain the correspondent averages and standard deviations. Each standard deviation of the average is calculated by dividing the sum of the standard deviation of each run's result by the square root of the number of runs (adjusted formula). The higher the number of runs used in a trial, the lower the standard deviation will be, and thus more accurate the estimates. However, given that each trial takes from 1 to 3 hours to run (this time depends on the size of the primary health care unit's model), we chose to use five runs as a compromise between accuracy in results and time demanded for running the model. The model was run on an Intel® CPU 1.60 GHz, with 2.00 GB of RAM, and using both the Simul8 13.0 and the Excel 2003 software.

Calculating the average value and the correspondent standard deviation allows us to present the final results as confidence intervals (CI). These CIs are interval estimations of a certain result, and are used to indicate the reliability of an estimate. In the present work, a 95% confidence interval was used for the average result obtained from the five runs of the trial. This 95% confidence interval is given by:

95% Confidence Intervals (CI) = Average of the Results ± 2 * *Average Standard Deviation*

The validation of the proposed model was performed by comparing whether the real values are within the intervals returned by the model. The following tables show the obtained results for the validation procedure. They are divided into six components, in accordance with available indicators: the total number of physician's consultations, the number of each type of consultations with a physician, the number of acute/emergency situations, the number of nursing consultations, the human resources enrolled and the total associated costs. These tables present the real values (Real), the values that result from our models (Model) and the percentage variation between both (Variation).

		Total Number of Ambulatory Consultations		
		Real	Model	Variation (%)
Benfica	PHCC Benfica	38464	[38356 ; 39579]	[-0,28 ; 2,90]
	PHCC Marchal Carmona	56609	[56948 ; 58011]	[0,6 ; 2,48]
	PHCC Carnide	26417	[25912 ; 26200]	[-1,91 ; -0,82]
	FHU Rodrigues Migueis	30065	[29676 ; 30238]	[-1,29 ; 0,58]
Sete Rios	PHCC Sete Rios	141671	[139235 ; 140607]	[-1,712 ; 0,75]
	FHU Tílias	26425	[24188 ; 25189]	[-8,47 ; -4,61]
Carnaxide	PHCC Linda-a-Velha	86720	[83899 ; 84913]	[-3,25 ; -2,08]
	PHCC Algés	54141	[53724 ; 54591]	[-1,27 ; 0,33]
	FHU Dafundo	33237	[33208 ; 33637]	[-0,08 ; 1,20]
Oeiras	PHCC Oeiras	83480	[78246 ; 79901]	[-6,27 ; -4,29]
	PHCC Paço de Arcos	70853	[67808 ; 69567]	[-4,30 ; -1,82]
	PHCC Barcarena	21783	[21696 ; 22109]	[-0,40 ; 1,47]
	FHU Delta	34042	[34135 ; 34574]	[0,27 ; 1,56]
	FHU São Julião	41186	[40538 ; 41164]	[-1,57 ; -0,05]
Cascais	PHCC Cascais	76881	[78160 ; 80415]	[1,66 ; 4,60]
	PHCC Estoril	61556	[61758 ; 63117]	[0,33 ; 2,54]
	PHCC Alvide	34636	[33785 ; 35599]	[-2,46 ; 2,78]
	PHCC Alcabideche	30631	[30883 ; 31094]	[0,81 ; 1,51]
	FHU Marginal	45198	[44115 ; 45088]	[-2,40 ; -0,24]

Table 8: Results obtained for the total number of ambulatory consultations

		Number of Adult Consultations			Number of Child Consultations			Number of Maternal Consultations			Number of Family Planning Consultations		
		Real	Model	Variation (%)	Real	Model	Variation (%)	Real	Model	Variation (%)	Real	Model	Variation (%)
Benfica	PHCC Benfica	32156	[32298 ; 33015]	[0,44 ; 2,67]	4498	[4421 ; 4534]	[-1,71 ; 0,8]	875	[871 ; 918]	[-0,46 ; 5,37]	935	[896 ; 912]	[-4,17 ; -2,46]
	PHCC Marchal Carmona	48234	[48543 ; 49379]	[0,63 ; 2,37]	5660	[5640 ; 5796]	[0,35 ; 2,47]	1312	[1345 ; 1378]	[2,52 ; 5,03]	1403	[1420 ; 1458]	[1,21 ; 3,92]
	PHCC Carnide	22509	[22070 ; 22137]	[-1,95 ; -1,65]	2641	[2600 ; 2712]	[-1,55 ; 2,69]	612	[615 ; 649]	[-0,49 ; 6,05]	655	[627 ; 702]	[-4,27 ; 7,18]
	FHU Rodrigues Migueis	27148	[26592 ; 27036]	[-2,05 ; -0,41]	2209	[2391 ; 2453]	[8,24 ; 11,05]	343	[331 ; 364]	[-3,50 ; 6,12]	365	[362 ; 385]	[-0,82 ; 5,48]
Sete Rios	PHCC Sete Rios	123770	[121938 ; 122781]	[-1,48 ; -0,80]	12894	[12578 ; 13013]	[-2,45 ; 0.92]	2188	[2098 ; 2120]	[-4,11 ; -3,11]	2803	[2621 ; 2693]	[-6,49 ; -3,94]
	FHU Tílias	24894	[24518 ; 24912]	[-1.50 ; -0.72]	580	[558 ; 603]	[-3,79 ; -3,97]	400	[389 ; 427]	[-2,75 ; 6,75]	551	[529 ; 554]	[-3.99 ; 0.54]
Carnaxide	PHCC Linda-a-Velha	72936	[70347 ; 71029]	[-3,55 ; -2,61]	10062	[9898 ; 10034]	[-1,63 ; -0,28]	1398	[1375 ; 1452]	[-1,65 ; 3,86]	2324	[2279 ; 2398]	[-1,94 ; 3,09]
	PHCC Algés	45540	[45227 ; 45910]	[-0,69 ; 0,81]	6282	[6219 ; 6302]	[-1,00 ; 0,32]	868	[888 ; 917]	[2,30 ; 5,45]	1451	[1390 ; 1462]	[-4,20 ; 0,75]
	FHU Dafundo	30947	[30918 ; 31193]	[-0,1 ; 0,79]	1171	[1168 ; 1205]	[-0,26 ; 2,93]	227	[229 ; 303]	[0,88 ; 3,34]	892	[893 ; 936]	[0,11 ; 4,93]
Oeiras	PHCC Oeiras	70296	[64847 ; 66028]	[-7,75 ; -6,07]	8588	[8741 ; 8888]	[1,78 ; 3,49]	1770	[1740 ; 1910]	[-0,17 ; 7,90]	2826	[2918 ; 3075]	[3,26 ; 8,81]
	PHCC Paço de Arcos	59663	[56848 ; 58103]	[-4,72 ; -2,61]	7289	[7141 ; 7391]	[-2,09 ; 1,43]	1502	[1503 ; 1612]	[0,06 ; 7,30]	2399	[2316 ; 2461]	[-3,46 ; 2,58]
	PHCC Barcarena	17721	[17738 ; 17878]	[0,09 ; 089]	2165	[2112 ; 2248]	[-2,63 ; 4,13]	446	[432 ; 482]	[-3,24 ; 8,33]	1451	[1414 ; 1501]	[-2,62 ; 3,54]
	FHU Delta	30072	[30214 ; 30402]	[0,47 ; 1,10]	1872	[1798 ; 1918]	[-3,95 ; 2,36]	640	[641 ; 679]	[0,16 ; 6,09]	1458	[1482 ; 1575]	[1,65 ; 8,02]
	FHU São Julião	37342	[36810 ; 37172]	[-1,42 ; -0,46]	2231	[2137 ; 2306]	[-4,40 ; 3,51]	501	[489 ; 512]	[-2,40 ; 2,20]	1112	[1102 ; 1174]	[-0,9 ; 5,58]
Cascais	PHCC Cascais	64468	[65782 ; 67527]	[2,04 ; 4,74]	8495	[8418 ; 8990]	[-0,91 ; 5,83]	1549	[1573 ; 1650]	[1,55 ; 6,52]	2369	[2387 ; 2448]	[0,67 ; 3,33]
	PHCC Estoril	51541	[51817 ; 52747]	[0,54 ; 2,34]	6792	[6831 ; 7119]	[0,57 ; 4,81]	1239	[1227 ; 1297]	[-0,97 ; 4,68]	1984	[1883 ; 1954]	[-5,09 ; 1,51]
	PHCC Alvide	29044	[28955 ; 29871]	[-0,31 ; 2,85]	3827	[3691 ; 3917]	[-3,55 ; 2,35]	698	[680 ; 712]	[-2,58 ; 2,01]	1067	[1046 ; 1099]	[1,97 ; 3,00]
	PHCC Alcabideche	25686	[26053 ; 26154]	[1,43 ; 1,82]	3384	[3345 ; 3411]	[-1,15 ; 0,80]	617	[579 ; 603]	[-6,16 ; -2,27]	944	[906 ; 926]	[-4,03 ; -1,91]
	FHU Marginal	41967	[40887 : 41712]	[-2,67 ; -0,61]	1600	[1584 ; 1649]	[-0,10 ; 3,06]	696	[688 ;719]	[-1,15 ; 3,30]	935	[956 ; 1008]	[2,25 ; 7,81]

Table 9: Results obtained for the number of each type of ambulatory consultations

		Number of Acute/Urgent Consultations		
		Real	Model	Variation (%)
Benfica	PHCC Benfica	7974	[7959 ; 8160]	[-0,19 ; 2,33]
	PHCC Marchal Carmona	11962	[11947 ; 11973]	[-0,13 ; 0,09]
	PHCC Carnide	5582	[5584 ; 5613]	[0,04 ; 0,56]
	FHU Rodrigues Migueis	1318	[1301 ; 1326]	[-1,29 ; 0,61]
Sete Rios	PHCC Sete Rios	20275	[19977 ; 20173]	[-1,47 ; 0,50]
	FHU Tílias	-	[4514 ; 4665]	-
Carnaxide	PHCC Linda-a-Velha	8095	[8350 ; 8574]	[3,15 ; 5,92]
	PHCC Algés	-	-	-
	FHU Dafundo	5907	[5634 ; 5798]	[-4,62 ; -1,85]
Oeiras	PHCC Oeiras	22099	[22580 ; 23095]	[2,18 ; 4,51]
	PHCC Paço de Arcos	-	-	-
	PHCC Barcarena	5571	[5450 ; 5597]	[-2,17 ; 0,47]
	FHU Delta	-	[5142 ; 5298]	-
	FHU São Julião	-	[6681 ; 6734]	-
Cascais	PHCC Cascais	11515	[11098 ; 11498]	[-3,62 ; -0,15]
	PHCC Estoril	-	-	-
	PHCC Alvide	-	-	-
	PHCC Alcabideche	-	-	-
	FHU Marginal	-	[7180 ; 7302]	-

Table 10: Results obtained for the acute/urgent consultations

		Number of Nursing Consultations			Type 1[3] Nursing Consultations			Type 2 Nursing Consultations		
		Real	Model	Variation (%)	Real	Model	Variation (%)	Real	Model	Variation (%)
Benfica	PHCC Benfica	15804	[16387 ; 16879]	[3,69 ; 5,16]	1876	[1947 ; 2039]	[3,78 ; 8,69]	13928	[14440 ; 14840]	[3,68 ; 6,55]
	PHCC Marchal Carmona	23706	[24275 ; 24397]	[0,24 ; 0,29]	2814	[2907 ; 2956]	[3,30 ; 5,05]	20892	[21368 ; 21441]	[2,23 ; 2,57]
	PHCC Carnide	11062	[11252 ; 11392]	[1,67 ; 2,98]	1313	[1389 ; 1448]	[5,7 ; 10,28]	9749	[9863 ; 9944]	[1,17 ; 2,00]
	FHU Rodrigues Migueis	12867	[12942 ; 13118]	[0,58 ; 1,95]	1593	[1734 ; 1811]	[8,85 ; 13,68]	11274	[11208 ; 11307]	[-0,59 ; 0,29]
Sete Rios	PHCC Sete Rios	72950	[76015 ; 78785]	[4,20 ; 8,00]	6612	[6907 ; 7037]	[4,46 ; 6,43]	66338	[69108 ; 71748]	[4,18 ; 8,16]
	FHU Tílias	14603	[13874 ; 14445]	[-4,99 ; -3,91]	2482	[2367 ; 2411]	[-4,63 ; -2,86]	12121	[11507 ; 12034]	[-5,07 ; -0,72]
Carnaxide	PHCC Linda-a-Velha	39038	[38634 ; 40670]	[-1,03 ; 4,18]	4859	[4581 ; 4742]	[-5,72 ; -0,42]	34179	[34053 ; 35928]	[-0,37 ; 5,12]
	PHCC Algés	26268	[27311 ; 28741]	[3,97 ; 9,47]	4927	[4768 ; 4894]	[-3,23 ; 0,67]	21341	[22543 ; 23847]	[5,63 ; 11,74]
	FHU Dafundo	16996	[17445 ; 18362]	[2,96 ; 8,04]	2889	[2743 ; 2849]	[-5,05 ; -1,38]	14107	[14702 ; 15513]	[4,22 ; 9,97]
Oeiras	PHCC Oeiras	30215	[31301 ; 32677]	[3,59 ; 8,15]	3761	[3987 ; 4212]	[6,01 ; 11,99]	26454	[27314 ; 28465]	[3,25 ; 7,60]
	PHCC Paço de Arcos	25644	[25336; 26178]	[-1,20 ; 2,08]	3192	[3030 ; 3230]	[-3,05 ; 1,19]	22452	[22336 ; 22948]	[-0,52 ; 2,21]
	PHCC Barcarena	7617	[8304 ; 8656]	[9,02 ; 13,64]	948	[979 ; 1059]	[3,27 ; 11,71]	6669	[7325 ; 7597]	[9,84 ; 13,82]
	FHU Delta	11935	[12636 ; 12900]	[9,20 ; 12,67]	2947	[3201 ; 3439]	[8,62 ; 16,69]	8988	[9435 ; 9461]	[4,97; 5,26]
	FHU São Julião	15648	[19346 ; 21427]	[23,63 ; 36,93]	2896	[3062 ; 3255]	[5,73 ; 12,40]	12752	[16284 ; 18172]	[27,70 ; 42,50]
Cascais	PHCC Cascais	51528	[53328 ; 54832]	[3,49 ; 6,41]	10617	[12034 ; 12829]	[13,35 ; 20,83]	40911	[41294 ; 42003]	[0,94 ; 2,67]
	PHCC Estoril	41195	[43953 ; 45306]	[6,69 ; 9,32]	8488	[9381 ; 9608]	[10,51 ; 13,20]	32707	[34572 ; 35698]	[5,70 ; 9,14]
	PHCC Alvide	23214	[22973 ; 23953]	[-1,04 ; 3,18]	4783	[4736 ;4925]	[-0,98 ; 2,97]	18431	[18237 ; 19028]	[-1,05 ; 3,24]
	PHCC Alcabideche	20530	[20627 ; 21574]	[0,47 ; 5,09]	4230	[4129 ; 4448]	[-2,39 ; 5,15]	16300	[16498 ; 17126]	[1,21 ; 5,07]
	FHU Marginal	17591	[14295 ; 15759]	[-18,74 ; -10,41]	2934	[2869 ; 2977]	[-2,25 ; 1,47]	14657	[11426 ;12782]	[-22,04 ; -12,79]

Table 11: Results obtained for the total number of nursing consultations and correspondent types

[3] Nursing Consultations were divided in two different types:

- Type 1: Diabetes, Child or Maternal Consultation
- Type 2: Consultation for Vaccination or other type of treatments

		Number of Physicians		Number of Nurses		Number of Receptionists	
		Real	Model	Real	Model	Real	Model
Benfica	PHCC Benfica	10	10	8	6	-	3
	PHCC Marchal Carmona	15	15	14	10	-	5
	PHCC Carnide	7	6	6	6	-	3
	FHU Rodrigues Migueis	6	6	7	6	5	3
Sete Rios	PHCC Sete Rios	36	36	29	24	-	6
	FHU Tílias	6	6	6	6	5	3
Carnaxide	PHCC Linda-a-Velha	16	16	16	16	-	5
	PHCC Algés	10	10	10	10	-	4
	FHU Dafundo	8	8	7	8	6	3
Oeiras	PHCC Oeiras	20	20	19	16	-	6
	PHCC Paço de Arcos	17	17	17	16	-	5
	PHCC Barcarena	5	5	4	5	-	3
	FHU Delta	8	8	8	6	5	3
	FHU São Julião	9	9	8	6	6	3
Cascais	PHCC Cascais	20	20	17	16	-	5
	PHCC Estoril	16	16	13	14	-	5
	PHCC Alvide	9	9	8	10	-	3
	PHCC Alcabideche	8	8	7	8	-	4
	FHU Marginal	10	10	9	10	8	4

Table 12: Results obtained for the number of personnel

		Total Costs(€)			
		Real	Model	Model	Variation (%)
Benfica	PHCC Benfica	5.352.514,32 €	[7.738.933 ; 7.900.164]	[2.007.936 ; 2.071.960]	[43.79 ; 46.89]
	PHCC Marchal Carmona			[2.981.228 ; 3.036.875]	
	PHCC Carnide			[1.356.493 ; 1.371.570]	
	FHU Rodrigues Migueis			[1.350.851 ; 1.376.433]	
Sete Rios	PHCC Sete Rios	6.058.671,30 €	[8.438.721 ; 8.556.590]	[7.288.952 ; 7.360.776]	[36,14 ; 40,42]
	FHU Tílias			[1.101.037 ; 1.146.603]	
Carnaxide	PHCC Linda-a-Velha	6.450.571,13 €	[8.764.357 ; 8.883.014]	[4.392.112 ; 4.445.195]	[35.12 ; 36,95]
	PHCC Algés			[2.812.451 ; 2.857.838]	
	FHU Dafundo			[1.511.628 ; 1.531.156]	
Oeiras	PHCC Oeiras	9.932.782,57 €	[11.639.538 ; 12.489.696]	[4.096.178 ; 4.182.817]	[17,18 ; 25,74]
	PHCC Paço de Arcos			[3.549.748 ; 3.641.832]	
	PHCC Barcarena			[1.135.785 ; 1.157.406]	
	FHU Delta			[1.553.825 ; 1.573.808]	
	FHU São Julião			[1.845.289 ; 1.873.785]	
Cascais	PHCC Cascais	10.463.105,77 €	[11.323.794 ; 13.163.011]	[4.091.676 ; 4.209.725]	[8,22 ; 25,80]
	PHCC Estoril			[3.233.031 ; 3.304.174]	
	PHCC Alvide			[1.768.644 ; 1.863.607]	
	PHCC Alcabideche			[1.616.725 ; 1.627.770]	
	FHU Marginal			[2.008.114 ; 2.052.405]	

Table 13: Results obtained for the total costs

Analysis of these tables indicates that:

- The general number of consultations carried out by physicians and nurses computed in the model generally match the correspondent real value. However, there are some exceptions. In the PHCC *Oeiras* and in the PHCC *Paço de Arcos*, the overall number of consultations carried out by physicians is around 5% lower than the real value. Several experiments were made in these models in order to approximate the results closer to reality, through a trial and error method. For example, we increased demand by decreasing time between new arrivals, but the total number of consultations did not change – only the queues got longer. These results suggest that these PHCC are working close to full capacity.
- As we made explicit when we described some of the assumptions of the model, the real values showed for FHU Delta, FHU São Julião and FHU Marginal are not completely reliable, due to the fact that these FHUs initiated their activity in the middle of 2007. Consequently, one expected a gap between the results of the model and production values we have considered (we converted production indicators for 1 semester for one year).
- Due to the lack of information about the number of receptionists working in primary health care centres, a sufficient number was used so that the waiting times in the reception would be acceptable. Thus waiting times for the reception given by the model will not be very reliable.
- With regard to costs, as we observe in Table 13, there are variations between the real values and the ones that outcome from the model. We used as parameters for our model the cost per consultation with personnel and cost per consultation with diagnosis tests and other treatments used on (Gouveia et al. 2007b), which assumed that "… FHU have similar costs to primary health care units that, in 2005, were operating under an Experimental Remuneration Regime (ERR)". We could not access better data, which has justified the use of this data that is not expected to produce good estimates of costs. Being aware of the limitations of this data, we have decided to analyse costs returned by the models, but instead of analysing absolute values, we analyse variations in costs whenever meaningful.
- It is important to refer that the *credibility* task implied during the modelling process (referred in 4.1.5) would require a manager or a project personnel to accept them as "correct" (Law 2000). On our models, this task was not performed as it would consume a great amount of time with contacts among RHAs', PHCCs' and FHUs' managers and decision makers.

In the previous tables we have compared estimated values with real data. In the next chapter, we compare indicators produced by our models for which there is no real data and that capture efficiency and quality differences in health care delivery in PHCC and FHU.

5. Results and scenario testing

In this chapter, we start by presenting the results for the year 2007 (after the calibration and validation of the model) for indicators for which there is no real data. We make use of the key performance indicators (KPIs) described in chapter 4. Afterwards, an important policy scenario is tested: what happens to the system when we convert all the primary health care centres into family health units? This scenario tries to capture the possible advantages or disadvantages that may arise from the complete application of the current primary health care reform defined by the Ministry of Health. Again, under this scenario we analyse the behaviour of key indicators.

5.1. Results for the year 2007

In this section, the results for 2007 are shown. It is important to refer that all these results are estimated by the model and no previous information about them is known, i.e. these are indicators suggested by the simulation models we have run. The results for 2007 are now presented, regarding the processes involved and described by the conceptual models: Appointment Scheduling, General Practitioner's Consultations, Acute/Emergency cases, Nursing Care and Costs.

Appointment scheduling:

Detailed results on the process of scheduling appointments with a physician are available in Appendix 2.

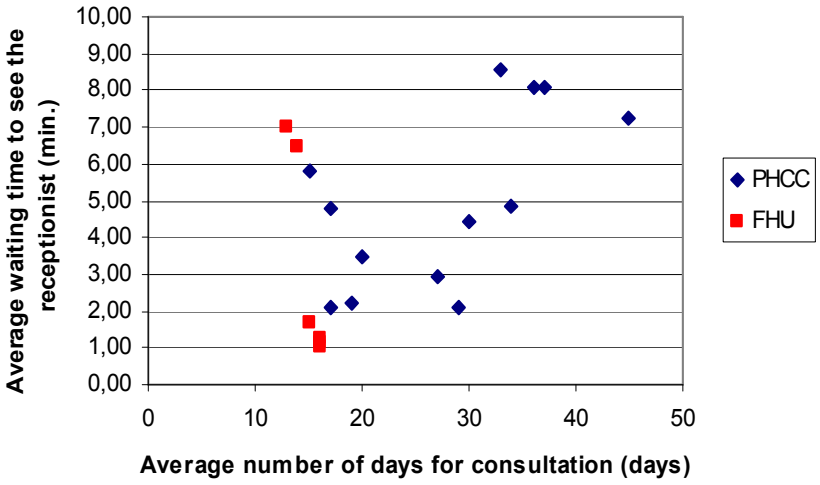


Figure 24: Average waiting time to see the receptionist vs. Average number of days for a consultation

Analysis of figure 24 and the complete data available in Appendix 2, we observe:

Main results:

- In FHU, patients have to wait a lower number of days in order to have a consultation with the GP. (~ 15 vs. ~ 30 days).
- Contrarily to PHCCs, in FHUs, the number of waiting days for a consultation is not affected by the size of the health care unit.
- As it was explained in 4.3.4, due to the lack of information about the number of receptionists/administratives working in primary health care units, the results obtained for this indicator are not reliable.

General practitioner's consultations:

Detailed results for physicians' consultation related indicators are presented in Appendix 3: Apart from the number of consultations per physician, all the other values were generated by the model and there is no available information on those.

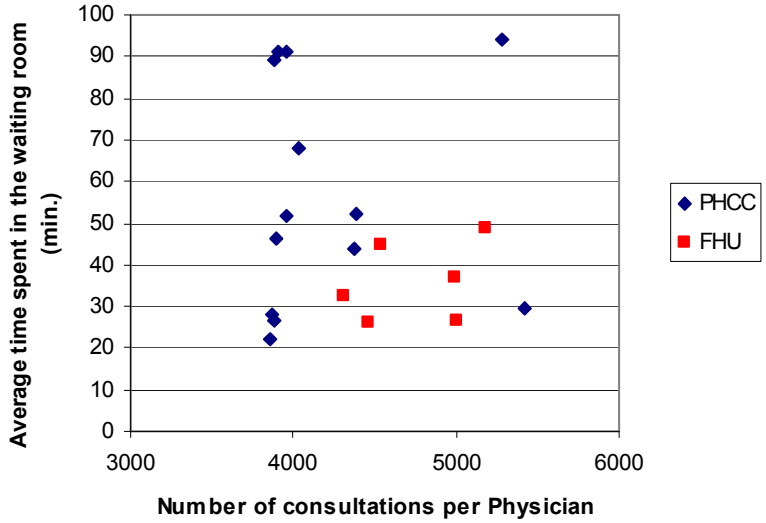


Figure 25: Average time spent in the waiting room vs. Number of consultations per physician

Comparing the number of consultations per physician with the average time spent by patients in the waiting room (Figure 25) and the information presented Appendix 3 we observe that:

Main results:

- The average number of consultations per physician in FHU is higher then in PHCCs.
- The average time that a patient spends in the waiting room is considerable lower in FHU.
- The average percentage usage of physicians is similar in PHCCs and FHUs.
- As we can observe, there are some outlier values, namely for the number of consultations per physician in PHCCs

Acute/Urgent cases:

Output performance indicators for acute/emergency services are available in Appendix 4. Analysis of data from Appendix 4 indicates that there is a higher homogeneity in FHU in the relationship between the average number of acute/urgent consultations per physician and the average waiting time for the patient to be taken care of.

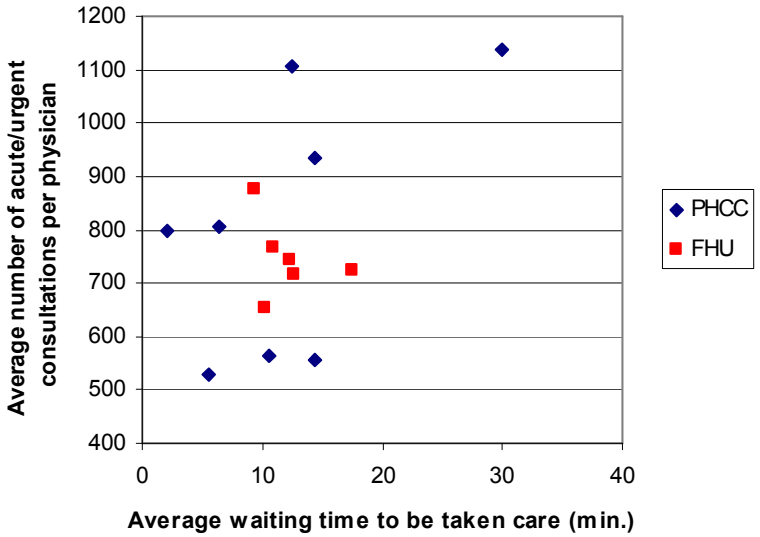


Figure 26: Average number of acute/urgent consultations per physician vs. Average waiting time for the patient be taken care of

Analysis of the previous figure and of data in Appendix 4 indicates that:

Main results:
▪ Despite the organisational changes, PHCCs and FHUs have similar waiting times for an acute/urgent patient (~ 14 minutes). Nevertheless, there is a much higher variation within PHCCs than in FHUs.

Nursing care:

The 2007 results for nursing consultation related indicators are available in Appendix 5. One should take into account that apart from the number of consultations per nurse (that was previously known), all the other indicators shown were estimated by the simulation models and no previous information about them is known. We decided to make comparisons between the average time for type 1 and type 2 consultations and the number of appointments by nurse.

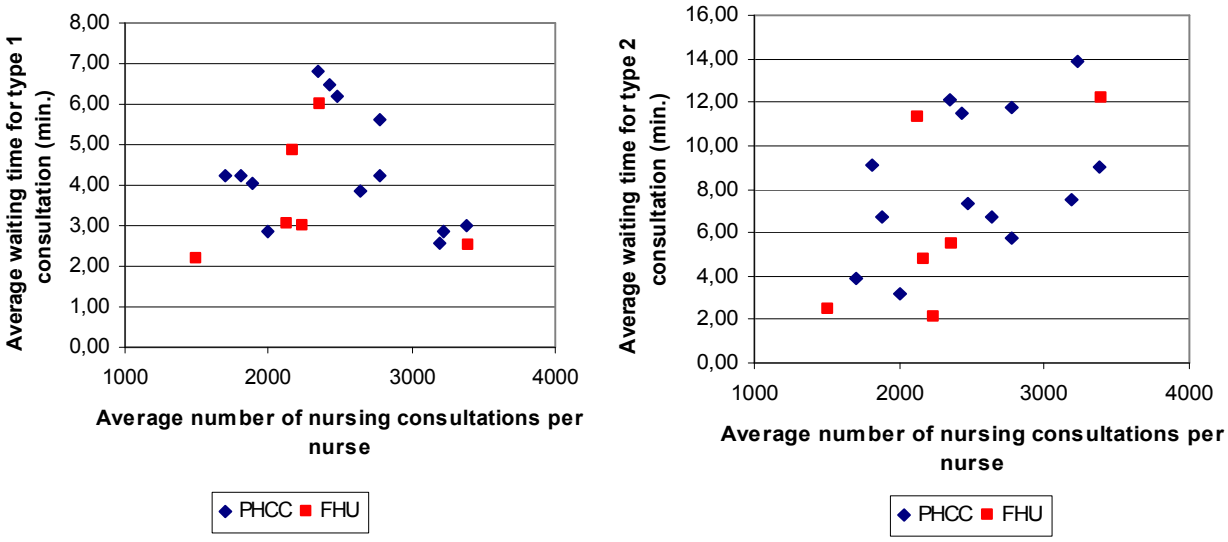


Figure 27: Average waiting time for type 1 and type 2[4] nursing consultations vs. Average number of nursing consultations per nurse

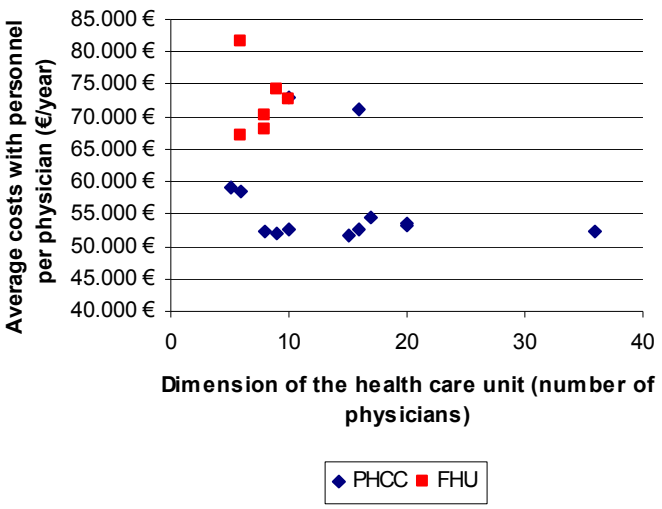
Analysis of the previous charts and information from Appendix 5 indicated that:

Main results:
▪ In FHUs the average time in the waiting room for a nursing consultation is lower, especially for Type 2 consultations.
▪ FHUs and PHCCs have a similar level of usage for nurses.

Costs:

The last indicators estimated for the year 2007 were costs. In Appendix 6 we have a detailed description of total costs, costs with personnel and costs with diagnosis tests and other treatments. However, it is important to remind that we have only had access to data from the (Gouveia et al. 2007b) study which is not expected to provide a good estimate of costs.

[4] It is important to refer that there are two different types of consultations inside nursing care:
- Type 1: Diabetes, child or maternal consultations
- Type 2: Consultations for vaccination or other type of treatments



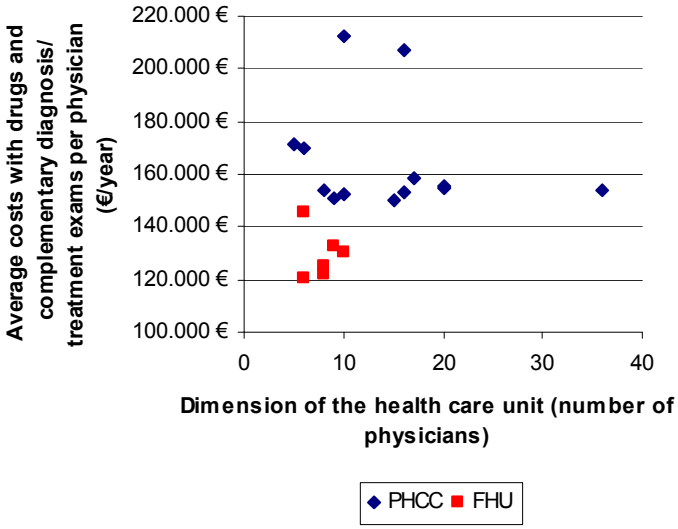


Figure 28 : Average costs with personnel per physician and average costs diagnosis tests and other treatments per physician per physician vs. the Number of physicians (Size of the health care unit)

Main results:

- The average costs with personnel per physician are slightly higher in FHUs.
- The average costs with diagnosis tests and other treatments per physician is significant lower in FHUs than in PHCCs.

We summarise in the next table the main findings from the analysis of 2007 results.

Appointment Scheduling
▪ In FHU, patients have to wait a lower number of days in order to have a consultation (~ 15 vs. ~ 30 days). ▪ Contrarily to PHCCs, in FHUs, the number of waiting days for a consultation is not affected by the size of the health care unit.
▪ Overall Performance Comparison: FHUs seem to have higher efficiency and quality in the scheduling appointment process.
Physicians' Consultations
▪ In FHUs, the average number of consultations per physician is higher then in PHCCs. ▪ The average time a patient spends in the waiting room is considerable lower in FHU. ▪ The average percentage of use of physicians is similar in PHCCs and FHUs
▪ Overall Performance Comparison: There seems to be higher efficiency and quality associated to physicians' consultations in FHU.
Acute/Urgent Case
▪ Primary health care centres and FHUs have similar average waiting times for an acute/urgent patient (~ 14 minutes)
▪ Overall Performance Comparison: Results suggest no significant differences between primary health care centres and FHUs' with regard to delivery of acute/emergency care.
Nursing Consultations
▪ In FHUs the average time in the waiting room for a nursing consultation is lower than for PHCC, especially for Type 2 consultations. ▪ Similar percentage of use of nurses in PHCCs and FHUs.
▪ Overall Performance Comparison: Results seem to suggest a slightly higher efficiency and quality in FHUs' nursing consultations in comparison to PHCC's.
Costs
▪ The average costs with personnel per physician are slightly higher in FHUs. ▪ The average costs with diagnosis tests and other treatments per physician is significant lower in FHUs than in PHCCs.
▪ Overall Performance Comparison: Regarding the results obtained for the costs with personnel and diagnosis tests and other treatments, no additional data then on (Gouveia et al. 2007b) was obtained.

5.2. Scenario testing

The use of simulation models allows for testing new ideas and hypothesis of behaviour in the primary care system. As described above, the developed models can be used to test the impact of policies. We present now the results from converting PHCCs into FHUs.

This scenario consists on converting all primary health care centres into family health units, while maintaining the total number of physicians, nurses and other human resources, i.e. each primary health care centre is split into several FHUs maintaining the total amount of working personnel. Then, we analyse what happens in the universe of primary care units of our sample, namely to the key performance indicators of the system, such as global waiting times, total number of consultations carried out, rates of usage of resources and cost variations.

This scenario corresponds to a policy of the MoH of extending the conversion of PHCCs into FHUs in Portuguese primary health care sector. With the intent to improve the accessibility and quality, a reconfiguration in primary care centres is being performed. During the last three years, several family health units have been created, reaching the present total number of 143. However, these FHUs constitute a small percentage of the total universe o primary health care units. This way, trying to analyse the consequences of a complete change on the type o health care provider, on a certain region, might constitute an important basis to understand whether the current reform effectively leads or not to the goal of improving the accessibility and quality within the primary health care sector.

Table 14 shows how PHCC were converted into FHU. All primary health care centres (Original PHCC) were transformed into family health units (Converted FHU), using as basis the validated models of previously studied FHUs (Basis' FHU). For example, PHCC Marchal Carmona was converted into two FHUs (named respectively FHU Marchal Carmona I and FHU Marchal Carmona II) using as the underlying model the validated models of FHU Delta and FHU Dafundo. The reason why these specific FHUs were used as basis for the conversion is because they have similar dimensions (same number of working personnel).

A critical difference must be highlighted on this conversion: differently to primary health care centres, FHUs usually do not work during the weekend. We must take this into account when analysing results. Still on Table 14, we should read that the symbol (*)in the Basis' FHU column means that in order to have the Converted FHU, a known FHU was used as a basis with some modifications within its dimensions (such as in the number of working personnel)

	Original PHCC	Converted FHU	Basis' FHU
Benfica	PHCC Benfica	FHU Benfica I	*
		FHU Benfica II	*
	PHCC Marchal Carmona	FHU Marchal Carmona I	FHU Delta
		FHU Marchal Carmona II	FHU Dafundo
Sete Rios	PHCC Sete Rios	FHU Sete Rios I	FHU São Julião
		FHU Sete Rios II	FHU São Julião
		FHU Sete Rios III	FHU São Julião
		FHU Sete Rios IV	FHU São Julião
Carnaxide	PHCC Linda-a-Velha	FHU Linda-a-Velha I	FHU Dafundo
		FHU Linda-a-Velha II	FHU Dafundo
	PHCC Algés	FHU Algés I	*
		FHU Algés II	*
Oeiras	PHCC Oeiras	FHU Oeiras I	FHU Delta
		FHU Oeiras II	FHU Delta
		FHU Oeiras III	FHU Tílias
	PHCC Paço de Arcos	FHU Paço de Arcos I	FHU São Julião
		FHU Paço de Arcos II	FHU Dafundo
	PHCC Barcarena	FHU Barcarena	*
Cascais	PHCC Cascais	FHU Cascais I	FHU Delta
		FHU Cascais II	FHU Delta
		FHU Cascais III	FHU Tílias
	PHCC Estoril	FHU Estoril I	FHU Dafundo
		FHU Estoril II	FHU Dafundo
	PHCC Alvide	FHU Alvide	FHU São Julião
	PHCC Alcabideche	FHU Alcabideche	FHU Dafundo

Table 14: Table with the conversions made from primary health care centres into FHUs

As we can observe in Table 14, from the initial 12 primary health care centres (PHCCs), that we have selected, we will have, after the conversion into FHUs, a total number of 26 Converted FHUs. This corresponds to what was described as splitting each large PHCCs into smaller subunits of FHUs, maintaining however the total number of working personnel. Thus, when we present the results of these Converted FHUs' performance indicators, despite of the 12 observations (points), each of them corresponds to a different number of observations, i.e. each point on the chart is the result of the over positioning of several points (the several constituting FHUs).

After the implementation of the previously explained transformations, the results of the converted models are now presented regarding the processes involved: Appointment Scheduling, General Practitioner's Consultations, Acute/Urgent cases, Nursing Care and Costs. The complete results are attached in Appendix 7, 8, 9, and 10, but only the most relevant data is now presented in the text with the help of charts and trendlines. It is important to notice that the observations included on the following charts concern exclusively the 12 converted PHCCs. This way, the improvements or losses that exist on each of them is analysed regarding their correspondent size. Moreover, it is important to emphasize that the reliability of all the results now presented depends on whether the behaviour of the Converted FHUs is similar to the ones that were used as a basis.

Trendlines are used to graphically display trends in data. Such analysis is also named regression analysis. By using regression analysis, through Microsoft Excel, it is possible to extend a trendline in a chart beyond the actual data to predict future values (Microsoft 2003).

This software has six different trend or regression types: linear, logarithmic, polynomial, power, exponential or moving average. After several tries, and knowing that the most accurate one corresponds to the one which R-squared value is higher, we chose to use the logarithmic trendline for the following presented charts. From the relation obtained between the change in a certain indicator of a primary care unit regarding its correspondent size, several blue dots were plotted (each dot corresponds to one PHCC that was changed, meaning that we will display 12 blue dots); the trends are display through an orange line.

Appointment scheduling:

From the complete set of data presented in Appendix 7, we selected the most relevant performance indicators' variations and presented them in order to the respective dimension of the health care unit. This comparison helps in assessing the possible gains or losses from this shifting of PHCC into FHUs.

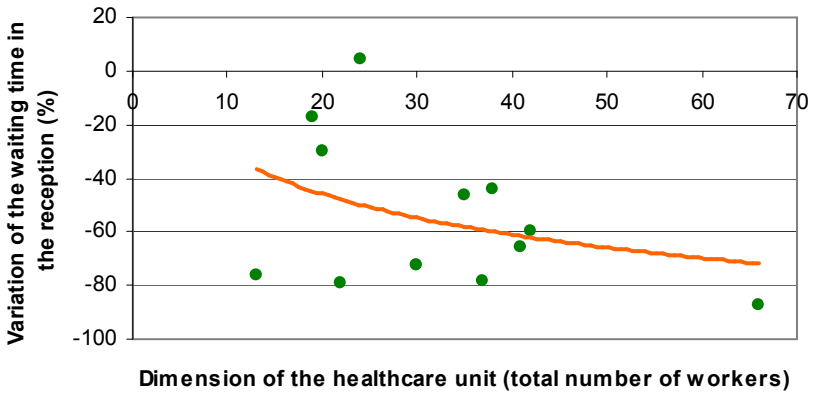


Figure 29: Variation in the waiting time in the reception vs. Dimension of the health care unit

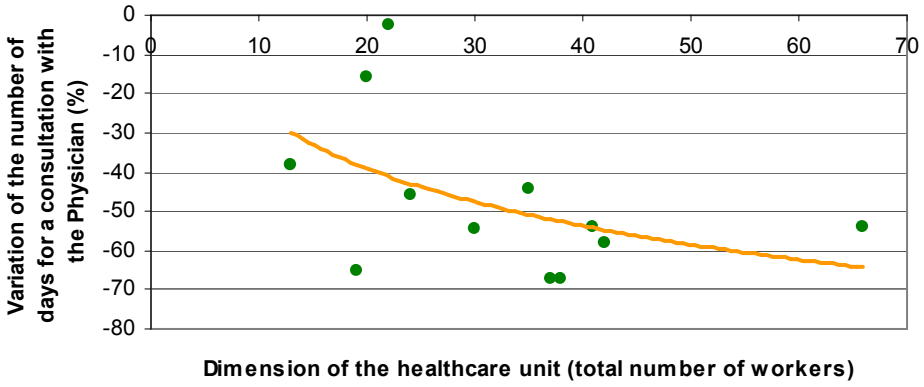


Figure 30: Variation in the number of days for a consultation with the physician vs. Dimension of the health care unit

Analysis of figures 29 and 30 and of data presented in Appendix 7 seems to suggest that:

Main results:

- From the conversion of PHCCs into FHUs, the waiting times within the reception are significantly reduced. This reduction is proportionally higher for larger FHUs.
- There is a significant reduction on the average number of days for a consultation, after converting PHCC into FHU. The larger the initial dimension of the PHCC, the larger that reduction, ranging from some weeks to more than a month.

General practitioner's consultations:

Analysis of the variation in the number of GP consultations indicates a substantial increase in the number of ambulatory consultations, as read in figure 31.

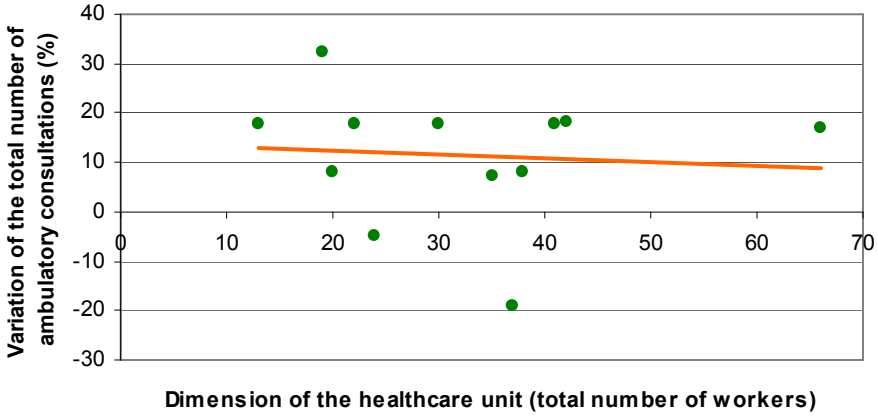


Figure 31: Variation in the total number of ambulatory consultations vs. Dimension of the health care unit

Regarding the variation in time a patient has to wait before he/she is taken care of by the physician for the consultation, the following chart indicates that there are increases in the smallest converted units and decreases in the largest converted units.

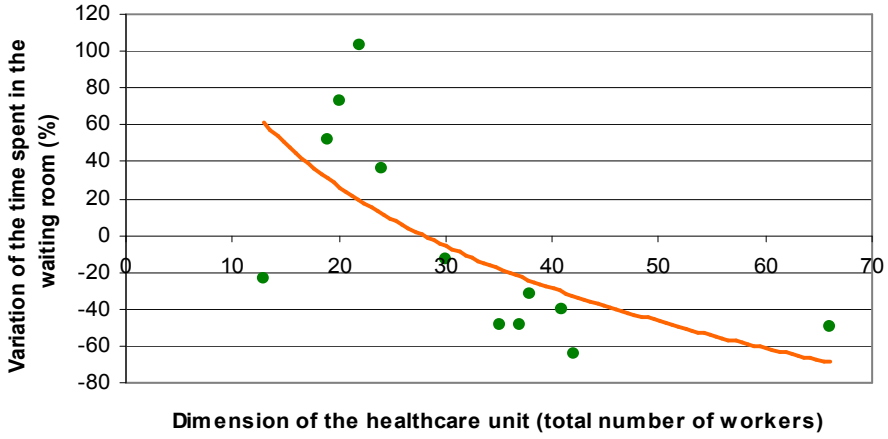


Figure 32: Variation in the time spent in the waiting room vs. Dimension of the health care unit

The last studied performance indicator for ambulatory consultations was the percentage of usage of physicians, for which results are shown in figure 33. Results indicate that the level of usage of physicians might overall increase.

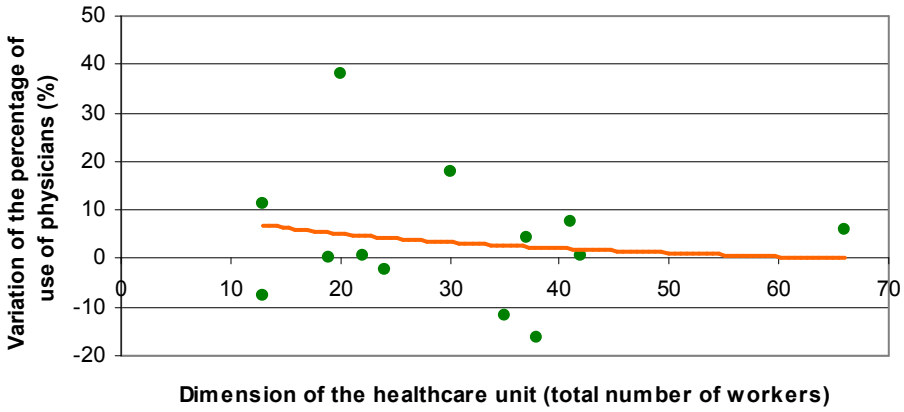


Figure 33: Variation in the percentage of use of physicians vs. Dimension of the health care unit

Analysis of the previous chart and the set of data in the Appendix 8 indicate the following:

Main results:

- With the conversion of PHCCs into FHUs, the potential capacity of these new health care units for ambulatory consultations increases on around 10%.
- The conversion of small PHCCs into FHU leads to an increase on the patient's average waiting time. For larger PHCCs, the same change leads to a lower patient's average waiting time to be taken care of.
- There is a slight increase in the percentage of use of physicians with the change into FHU – this indicator is increased to around 86% of use of physicians.

Acute/Urgent cases:

Detailed results on acute/emergency patients are presented in Appendix 9. A closer look at the variation in the most relevant key performance indicators is now made and presented in the following charts. The first compares the variation in number of acute/urgent cases with the dimension of the health care unit.

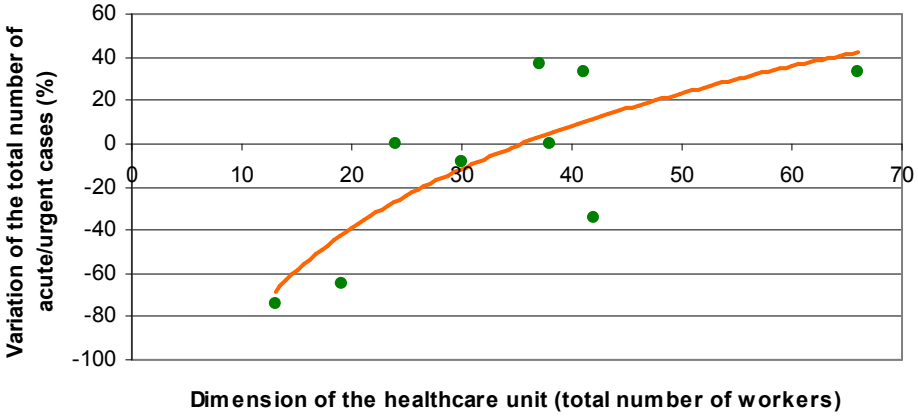


Figure 34: Variation in the total number of acute/urgent cases vs. Dimension of the health care unit

This second chart compares the variation in waiting time for acute cases with the dimension of health care units.

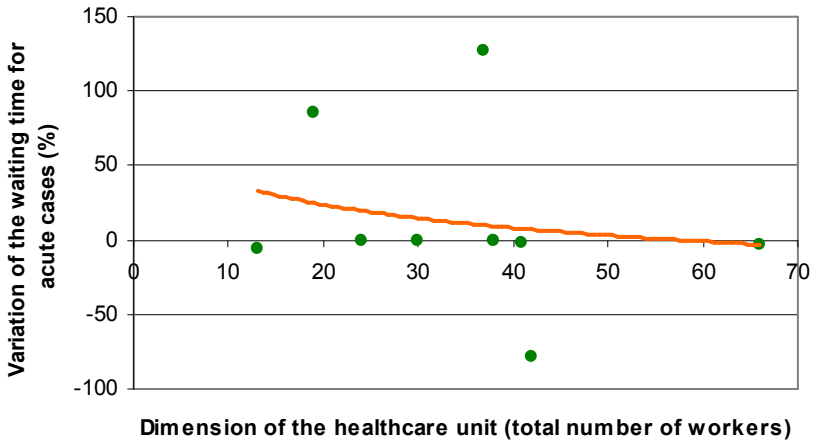


Figure 35: Variation in the waiting time for acute/urgent cases vs. Dimension of the health care unit

Analysis of the previous charts and of data from Appendix 9 shows as main results:

Main results:

- For small PHCCs there is a reduction of the capacity for total number of acute/urgent consultations when they change into FHUs. The larger the PHCCs, the larger the increase in answering to acute cases.
- Despite these converted FHUs do not operate during the weekends, results suggest that shifting from a PHCC centre into a FHU allows for efficiency gains within the acute/emergency care sector.

Nursing care:

When the results for 2007 were presented, it was referred that there were no differences between primary health care centres and FHUs with regard to the number of nursing consultations per nurse. This same indicator was again analysed, but results now differ.

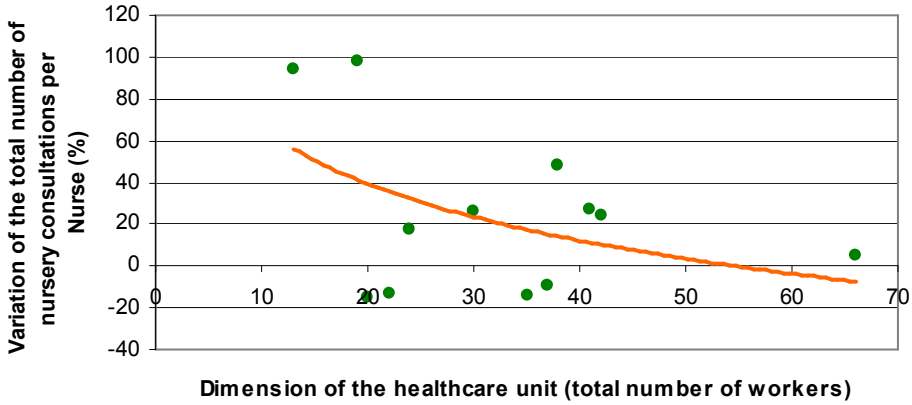


Figure 36: Variation in the total number of consultations per nurse vs. Dimension of the health care unit

Additionally, in order to have a closer view of type 1 and type 2 consultation's gains after the shifting into FHU, the following charts are presented:

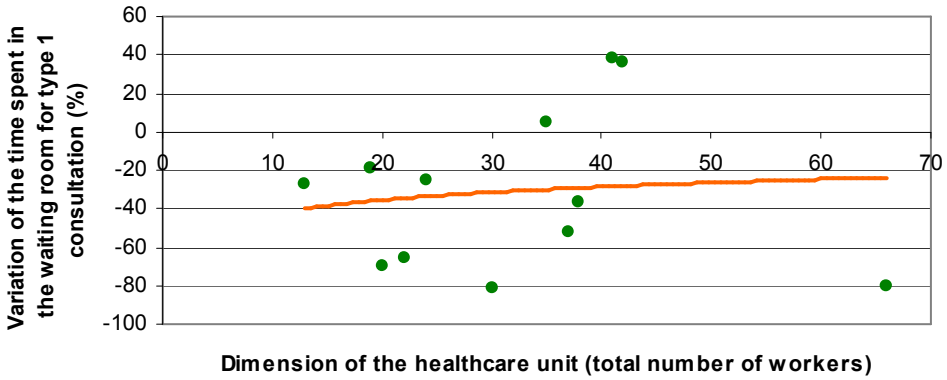


Figure 37: Variation in the time spent in the waiting room for Type 1 nursing consultations vs. Dimension of the health care unit

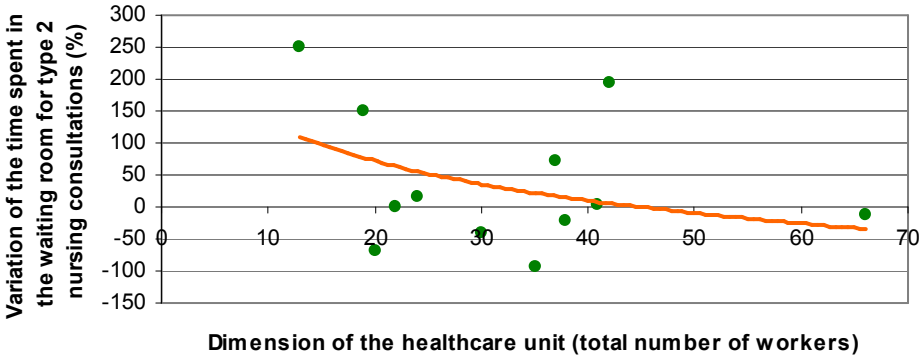


Figure 38: Variation in the time spent in the waiting room for type 2 nursing consultations vs. Dimension of the health care unit

The last nursing consultation's performance indicator that we find relevant to present is the variation in the percentage of use of nurses in order to the dimension of the health care unit.

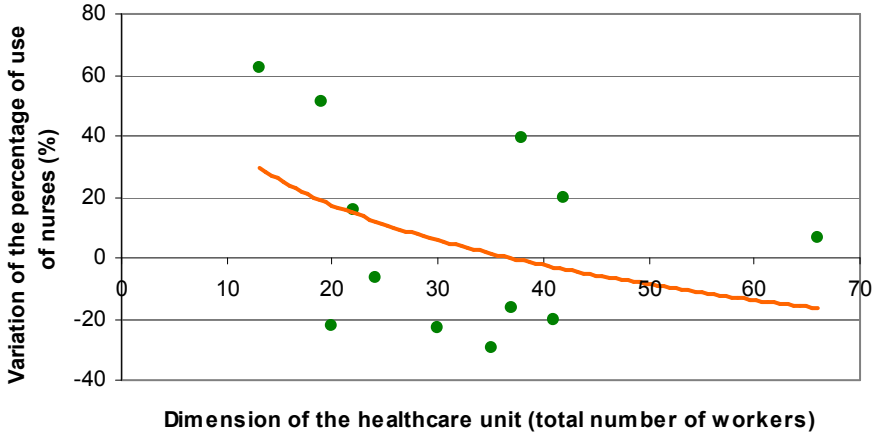


Figure 39: Variation in the percentage of use of nurses vs. Dimension of the health care unit

Analysis of the previous charts and of data available in Appendix 10 shows as main results:

Main results:

- Converting small PHCCs into FHUs leads to a significant increase on the capacity for carrying out nursing consultations. Converting larger PHCCs into FHUs presents no significant changes.
- There is an overall reduction on the waiting time for nursing consultations, especially for type 2 consultations (consultations for vaccination or other type of treatments). This means that setting up nursing consultations (one of the most radical changes between primary health care centres and FHU) is expected to lead to efficiency gains.
- The shifting into FHUs leads to increased efficiency on the use of nurses in small PHCCs and to no significant changes in larger PHCC.

Costs:

All data concerning the costs that result from the conversion of primary health care centres into FHUs is presented in Appendix 11. It is remind that despite the limitations of these parameters, we tried to overcome them by analysing variations in costs rather than analysing absolute values. Variations of these costs are now schematized, regarding the dimension of the primary health care unit:

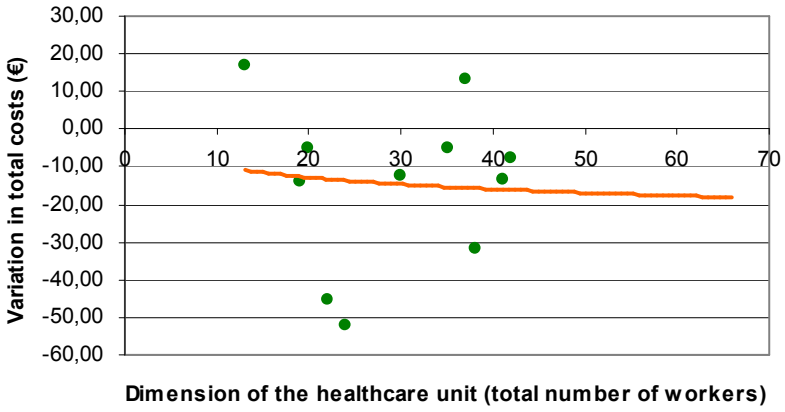


Figure 40: Variation in total costs vs. Dimension of the health care unit

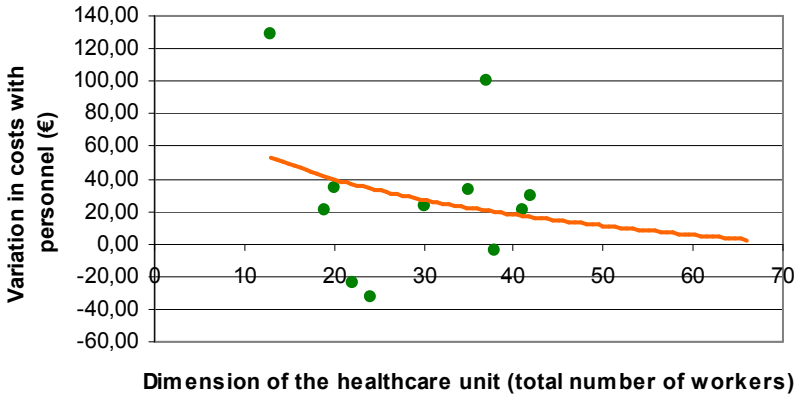


Figure 41: Variation in costs with personnel vs. Dimension of the health care unit

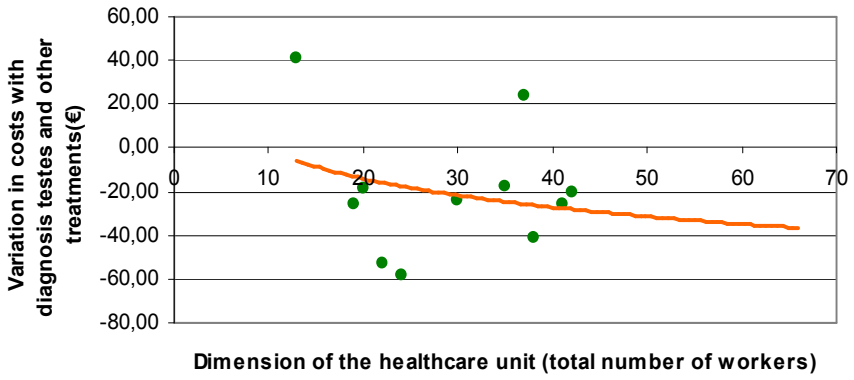


Figure 42: Variation in costs with diagnosis tests and other treatments vs. Dimension of the health care unit

An additional consideration was made in order to estimate the possible costs' gains that result from converting PHCC into FHUs. We present the variation in total costs vs. the number of ambulatory consultations per medical personnel and we observe that the largest the number of consultations per physician, the highest the scope for decreasing total costs.

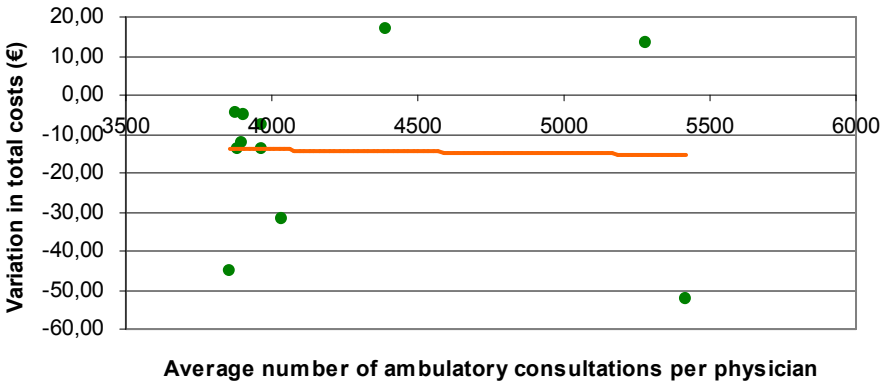


Figure 43: Variation in total costs vs. Average number of ambulatory consultations per physician

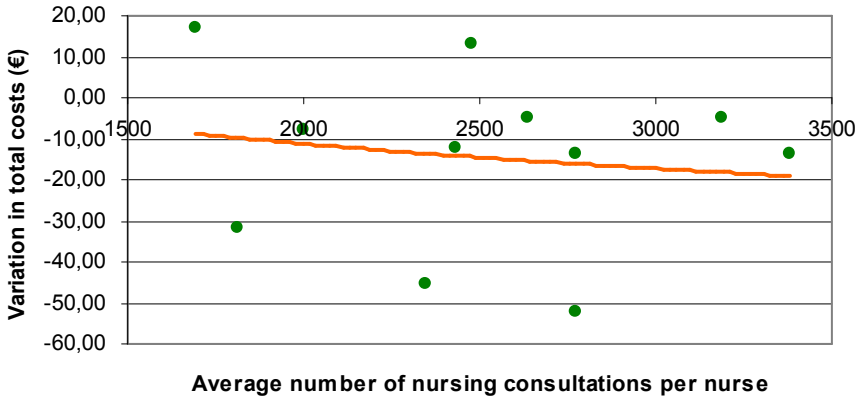


Figure 44: Variation in total costs vs. Average number of ambulatory consultations per physician

Analysis of the previous charts and of information presented in Appendix 11 shows us that:

Main results:

- There is a small increase in the overall costs from the shift of smaller PHCCs but, the bigger these units are more significant is the reduction on these costs (results suggest a potential reduction on overall costs on about 50% for bigger units).
- The higher the number of consultations carried out by physicians and nurses the greater the cost reduction.

To sum up, extending the FHU organizational model to our sample of primary care units leads to:

Appointment Scheduling
▪ From the conversion of PHCCs into FHUs, the waiting times within the reception are significantly reduced. This reduction is proportionally higher for larger FHUs. ▪ There is a significant reduction (around 50%) on the average number of days for a consultation, after converting PHCCs into FHUs. The larger the initial dimension of the PHCC, the larger that reduction, ranging from some weeks to more than a month.
Physicians' Consultations
▪ With the conversion of PHCCs into FHUs, the potential capacity of these new health care units for ambulatory consultations increases on around 10%. ▪ The conversion of small PHCCs into FHUs leads to an increase on the patient's average waiting time. For larger PHCCs, the same change leads to a lower patient's average waiting time to be taken care of. ▪ There is a slight increase in the percentage of use of physicians with the change into FHU – this indicator is increased to around 86% of use of physicians.
Acute/Urgent Case
▪ For small PHCCs there is a reduction of the capacity for total number of acute/urgent consultations when they change into FHUs. The larger the PHCCs, the larger the increase in answering to acute cases. ▪ Despite these converted FHUs do not operate during the weekends, results suggest that shifting from a PHCC into a FHU allows for efficiency gains within the acute/emergency care sector.
Nursing Consultations
▪ Converting small PHCCs into FHUs leads to a significant increase on the capacity for carrying out nursing consultations. Converting larger PHCCs into FHUs presents no significant changes. ▪ There is an overall reduction on the waiting time for nursing consultations, especially for type 2 consultations (consultations for vaccination or other type of treatments). This means that scheduling setting up nursing consultations (one of the most radical changes between primary health care centres and FHU) is expected to lead to efficiency gains. ▪ The shifting into FHUs leads to increased efficiency on the use of nurses in small PHCCs and to no significant changes in larger PHCCs.
Costs
▪ There is a small increase in the overall costs from the shift of smaller PHCCs but, the bigger these units are more significant is the reduction on these costs (results suggest a potential reduction on overall costs on about 50% for bigger units). ▪ The higher the number of consultations carried out by physicians and nurses the greater the cost reduction.

6. Discussion

In this chapter we discuss results presented in Chapter 5. We start by discussing the results obtained from comparing differences between the two types of organizational models in Portugal: PHCC vs. FHU. Our discussion is structured in the several operational processes that integrate the work in primary care centres – Appointment Scheduling, General Practitioner's Consultation, Acute/Urgent Consultation, Nursing Consultation – and for Costs.

6.1. Results for the year 2007

Appointment scheduling:

The analysis of the obtained results allows us to take some conclusions. First, results suggest that patients from FHUs wait a significantly lower average number of days for a consultation. This value corresponds to 15 days for FHUs and around 30 days for primary health care centres. It is also possible to observe this key performance indicator does not vary significantly with FHU size. The opposite seems to happen with PHCCs, whereas the average number of days for a consultation depends on the size of these health care units, originating a wide range of values.

Concerning the average waiting time to see the receptionist, results are as expected: there are no significant differences between primary health care centres and FHUs. In both organizations their values oscillate inside a wide interval, going from one minute to almost nine minutes. Nevertheless, given that we had no reliable data on receptionists, the indicator of waiting time for a receptionist also entails poor information. The same happens with the indicator of percentage of use of receptionists is similar and relatively low.

General practitioner's consultations:

Results indicate that the value of number of ambulatory consultations per physician is higher for FHU than for PHCC. A slight difference exists in the average time spent in the waiting room in FHU and PHCC, but generally, a patient in a primary health care centre has to wait more time in order to be taken care of by the physician. Evidence points out for efficiency and quality in GP consultations in FHUs in comparison to PHCCs.

Acute/Urgent cases:

It is possible to observe that no significant differences exist on the average waiting time for an acute/urgent patient to be taken care of in PHCCs and in FHUs. If we recall the differences between PHCCs and FHUs (the Complementary Service of PHCCs has its own physicians,

working on predetermined shifts, in the FHUs' Urgent/Day Appointment, due to some gaps that exist, intentionally, in the physician appointment schedule, acute cases can be taken care of on those gaps, with preference by the GP responsible for the patient), results arise interesting issues: despite changes in services organization, there are no substantial losses on access to this service.

We also observe that the there is one value for the average waiting time that clearly points out from the others. This is the case of the significant high average waiting time for the complementary service of the PHCC Oeiras (around 30 minutes). The reason for this high value is that if we analyse the total number of urgent cases this primary health care centre takes care of per year (around 22753 cases) and compare it with the corresponding value for a same size primary health care centre (PHCC Cascais with around 11298 urgent cases per year), it emerges there is a significant overload of PHCC Oeiras' complementary service which consequently leads to high waiting times for acute patients.

Nursing care:

Comparison of waiting times for nursing consultations shows that for some types of nursing consultations, waiting times are lower for FHUs than for PHCC (this is the case of consultations for vaccination or other type of treatments). This suggests that the changes on processes with regard to setting up nursing consultations in FHU might contribute to higher efficiency in the delivery of care.

It is also possible to verify that there are no significant differences between PHCC and FHU average percentage of use of nurses. We found out that the percentage of nurses used is around 60/70% in both organizational models, meaning that nurses' schedule in the built models is not fully occupied. Nurses have thus spare time that might be being used with other activities (such as answering phone calls, making home visits); or if that is not the case, nurses might be given more work.

Costs:

Results on costs are as expected. In FHUs, the average cost with personnel is slightly higher than in PHCC. However, the opposite happens with the costs with diagnostic testes and other treatments, whereas this indicator is significantly lower in FHUs. The obtained results, as we can observe, confirm was found out in the (Gouveia et al. 2007b) study. Again, it is important to refer that the quality of cost data in use is questionable (data not taken from FHU accounting systems) and thus results must be interpreted with caution.

6.2. Conversion of all primary health care centres into family health units

A discussion of the results from converting PHCC into FHU is now presented.

Appointment scheduling:

Several important considerations should be made about changing the process of setting up a consultation in the conversion from primary health care centres into family health units. Results indicate that the larger the primary health care centre, the larger will be the reduction on the waiting time in the reception and on the number of days a patient has to wait for a consultation, being this is a key finding. This reduction in the number of days for a consultation takes the amount of 50%. Consequently, this reform has the potential to improve substantial gains on scheduling appointments that lead to gains in access of populations to care.

General practitioner's consultations:

The conversion of PHCC into FHUs has the potential to increase production of ambulatory consultations on around 10%. This means that, with the same resources, the number of ambulatory consultations per physician can be improved with organizational changes. This result might be explained by the fact that in FHUs there are no patients without a physician, i.e. every patient has his own correspondent GP, and there is a higher level of GP substitution within FHU teams of physicians. Also, given that the first FHU were driven by GP highly motivated for organizational changes, results might be influenced by motivational effects that might not apply to GP from current PHCC. This behavioural hypothesis has been suggested by (Gouveia et al. 2007a). According to this study, there might be a self-selection effect proving that physicians that work in the first FHUs have a past background of carrying out the highest number of consultations, i.e. while working in primary health care centres they were usually the professionals with higher levels of productivity and with the highest eagerness to start working Family Health Unit with different organizational rules and payment systems. The potential increase of 10% in the 'production' of ambulatory consultations might contribute for solving the problem of having population not allocated to a GP, whereas this situation is common in primary health care centres, thus being a key finding.

The variation in the time that patients need to wait for the consultation after arriving to the primary care unit behaves in the following way: when small PHCC are converted into a FHU, their patients have their waiting time in the increased; for large PHCC, the opposite happens, i.e. patients average waiting time in the primary care unit diminish. This might be partly explained by the organization of FHU. As explained in previous chapters, each physician in a FHU is responsible for his own ambulatory and acute/urgent patients. If an acute/emergent patient enters the FHU simultaneously with a patient that has previously set up the consultation

for that hour and for the same physician, the later patient will usually have to wait longer so that the emergent situation is first taken care of. In primary health care centres, the complementary service is run separately and independently from ambulatory consultations, i.e. there are physicians allocated exclusively for acute/urgent situations and others for only for ambulatory. This means that, usually, emergent situations will not affect the normal running of ambulatory. So, in small primary health care centres where the average waiting time for an ambulatory consultation is usually low, changing to FHU will potentially increase this indicator. However, in large primary health care centres where usually the time for a patient to wait for a consultation within the unit is significantly high, the overall waiting time after conversion into a FHU is lower. We can conclude that there is a potential for decreasing waiting times within primary care units in large PHCC, and thus improving efficiency and quality in health care delivery.

With regard to the percentage of use of physicians, changing PHCC into FHU affects mainly that indicator for small PHCC. In these small units, where the percentage of use of physicians is lower than in bigger ones, changing to FHU originates a slight increase on this indicator. In large primary health care centres, where the percentage of use of physicians is usually high, this change does not produce significant changes on this output.

Acute/Urgent cases:

It is possible to verify that variation in the total number of acute/emergency consultations depends also on the dimension of the PHCC. There is a reduction on production for acute/emergency consultations for small PHCC when they change into FHUs; the larger the PHCC, the greater the potential increase on the number of acute cases.

Contrarily to what was expected, we observed an increase on the waiting time for acute cases for smaller PHCC. The explanation for this trendline might be behind the existence of some outlier values. As we can observe, there are three outliers. Two of them are PHCC (PHCC Benfica and PHCC Linda-a-Velha) whose initial average waiting times suffer a significant increase with the conversion into FHUs. This suggests that the complementary service within the PHCC organizational model was running more fluently before shifting into FHU. The third outlier value corresponds to PHCC Oeiras. As we previously noticed, the number of emergent cases associated with this primary health care's complementary service is fairly large, leading to congestion. After the conversion into a FHU the correspondent average waiting time suffers a significant reduction showing that, apparently, shifting into a FHU allows the primary health care unit to deal with this large number of acute cases within reasonable waiting times.

We conclude that, overall, despite converting PHCC into FHU, patients waiting time for an emergent consultation remains the same. This is positively surprising because, contrarily to PHCC, in FHUs there is not an independent and specific acute service for these patients. Thus,

shifting from a primary health care centre into a FHU seems to allow for resources savings without a lost on the efficiency and quality of this acute service.

Nursing care:

When the results for 2007 were presented, we found no significant differences on the number of nursing consultations per nurse in PHCC and in FHU. When we convert PHCC into FHU, we find that: there are no significant changes for large PHCC, while there is an increase in the number of consultations for smaller PHCC. This might be explained by the fact that nursing services might already be working close to maximum capacity in large PHCC.

When we analyse consultation by type, we find that a conversion into FHUs leads to an overall decrease on the waiting time for type 1 nursing consultations (diabetes, child or maternal consultations); for type 2 consultations (consultations for vaccination or other type of treatments), we verify that this change into FHUs (where nursing consultations are usually previously set up) in small PHCC leads to an increase on this waiting time, while on large PHCC there is a reduction. This means improvements for the largest PHCC.

Results on the percentage of usage of nurses, we observe that this indicator increases for small PHCC; for large PHCC this indicator is slightly reduced. This might be partly explained by the fact that, contrarily to small PHCC, larger PHCC nursing services are usually working near their maximum capacity. This way efficiency improvements are mainly expected in small PHCC.

Costs:

Analysis of costs should bear in mind the characteristics of data in use. As described earlier, the estimated values from the APES II study (Gouveia et al. 2007b) were used for the costs per consultation with personnel and for the costs per consultation with drugs and complementary diagnosis/treatment exams. However, as we described in the validation step, the resulting comparison between the real costs and the costs returned by the model revealed differences between both values. We have thus chosen to analyse variations in costs rather than absolute values.

A closer look at the results obtained for costs indicates that the variation of total costs that result from converting PHCC into FHUs greatly depends on the size of the PHCC. Results indicate an increase on overall costs for smaller PHCC. In this case, despite the slight reduction on costs with diagnosis and other treatments, the increase in the costs is mainly caused by a significant increase in the costs with personnel. However, for large PHCC, conversion into FHU leads to greater reductions on costs. Not only there is a slight decrease in the costs with personnel, but also, and more decisively, the costs with diagnosis and other treatments are greatly reduced.

These costs reductions suggest that efficiency and cost improvements are possible for larger PHCCs.

Concerning the relation between productivity and costs, results seem to suggest that the higher the productivity of these converted PHCCs, more significant are the costs' reductions. Thus, the higher the number of consultations carried out per physician or nurse, lower will be the total costs associated with these units.

Recalling what was previously referred, the reliability of all the results that were just presented depends on whether the behaviour of the converted FHUs is similar to the ones that were used as a basis. Thus, the key findings for the policy of the MoH of extending the conversion of PHCCs into FHUs in Portuguese primary health care sector are:

- A potential increase of 10% in the 'production' of ambulatory consultations that might contribute for solving the problem of having population not allocated to a GP.

- The reduction in the number of days for a consultation takes the amount of 50%. This means that substantial gains on scheduling appointments and consequently gains in access of populations to care are achieved with this reform.

- Regarding acute cases, we can conclude that there is a potential for decreasing waiting times from the shifting of large PHCCs, and thus improving efficiency and quality in health care delivery.

- Regarding the costs, results suggest that the variation of total costs resulting from the conversion of PHCCs into FHUs greatly depends on the size of the PHCCs. Results indicate an increase on overall costs for smaller PHCCs, however, for large PHCCs, conversion into FHUs leads to greater reductions on costs.

7. Conclusions and future developments

The purpose of the present thesis was to evaluate one of latest and more innovative reforms recently implemented by the Portuguese government in the primary health care sector – the creation of family health units. Our study has compared the performance of two primary care unit organizational models (PHCC vs. FHU) and analysed which gains and losses in the system might appear with the conversion of PHCC into FHU. Discrete event simulation models were developed in order to compare the performance of these family health units vs. primary health care centres. We found out these tools helped in analysing the two organizational models. Discrete event simulation models are characterized for considering random variables and also for describing the events of the system as occurring in individual and isolated instants of time, making them dynamic, stochastic and discrete, and able to test changes in a system.

In this thesis we started by characterising the Portuguese primary care system and then, we have reviewed evidence on studies analysing the impact of primary care reforms. Very few national or international studies evaluating organizational models were found.

We aimed at evaluating ongoing reforms and thus to produce knowledge that might help Portuguese policy makers. Thus, two generic conceptual models for FHU and PHCC were built entailing organizational models that mainly differ on: regarding the appointment scheduling, in FHUs, besides the possibility to set up a consultation for physicians there is also, contrarily to PHCCs, scheduling for nursing care; for physician's appointments, both in primary care centres and in FHUs, the consultations with the GP are previously set up for a specific day and hour. However, in FHUs there are no patients without an associated physician. This means that, in a FHU, patients are taken care and treated by the same GP the majority of the times. On rare occasions, when that does not happen, there is inter-substitution between physicians, potentially leading to higher level of production and satisfaction to the patient; regarding acute situations in some primary care centres, there might exist a service for acute situations named Complementary Service. This service has its own physicians, working on predetermined shifts. This means that this service is only available in certain days and at certain time periods. On the other hand, there is the so called Urgent/Day Appointment in FHUs. It is also a service designed for acute cases. Despite working differently – due to some gaps that exist, intentionally, in the physician appointment schedule – these acute cases can be taken care of on those gaps, with preference by the GP responsible for the patient. If the correspondent GP is not available, another GP might take care of that patient (inter-substitution). This way, as long as the FHU is opened, acute cases might be taken care of if resources are available in the FHU. Usually, FHUs do not operate during the weekends, which implies that patients under acute situations will need to access the correspondent primary health care centre or hospital; for nursing care, the most significant difference between primary care centres and FHU is the possibility on FHU to set up an appointment to a specific day and hour. In primary care centres patients are taken

care of in a first in, first out logic; finally, regarding costs, primary health care centres are ruled by the public administration's legislation, usually corresponding to an exclusive 42 hours/week period salary. On the other hand, FHUs can be organized according to two main models: either the personnel's remuneration is ruled by the public administration's legislation, corresponding to an exclusive 35 hours/week period (Model A) or the remuneration process is formed by two components: a fixed and a variable one. The fixed component corresponds to the legislated remuneration for an exclusive 35 hours/week period and the variable one corresponds to all supplements that derive from the worker's and FHU's performance (Model B)

Due to the high complexity around the definition of models representing the processes of PHCC and FHU, we made use of assumptions and simplifications. We have built conceptual models for PHCC and FHU and implemented them in the Simul8 software program; and we have applied these models to PHCC and FHU from three municipalities of the Greater Lisbon sub-region: *Lisbon*, *Oeiras* and *Cascais*. Throughout the development of this thesis, some specific challenges were faced. The main one was the difficulty in obtaining official and reliable data to calibrate the models' parameters and to validate the model. The collected information was sometimes either incomplete or presented in a format that made it difficult the process of calibrating and validating the several constituents of the models. Consequently, there might be inadequacies in the information systems being used in the primary care sector, or produced data is not released for public use. The development of future simulation models requires the use of higher quality data. Finally, it is important to refer again that the reliability of all the results that were presented depends on whether the behaviour of the Converted FHUs is similar to the ones that were used as a basis

After the calibration and validation process, estimates of key performance indicators were analysed for both the organizational types of primary care units. Results suggest that in FHUs, patients have to wait a lower number of days in order to have a consultation (~ 15 vs. ~ 30 days). Moreover, the average time a patient spends in the waiting room is considerable lower in FHU.

We have also tested the impact of a meaningful policy scenario: we have analysed the expected impact of extending the FHU model to our sample of primary care units, assuming that they might be converted into FHU similar to the ones already existing. The results obtained for this reform suggest that the key impacts are: a potential increase of 10% in the 'production' of ambulatory consultations that might contribute for solving the problem of having population not allocated to a GP; there is a reduction in the number of days for a consultation in 50%, meaning that substantial gains on scheduling appointments and consequently gains in access of populations to care are achieved with this reform; regarding acute cases, we can conclude that there is a potential decrease on waiting times from the shifting of large PHCCs, and thus improving efficiency and quality in health care delivery; finally, regarding the costs, results

suggest an increase on overall costs for smaller PHCCs and the opposite (cost reductions) for the conversion of large PHCCs into FHUs.

To sum up, and being aware of the limitations of this study, two main conclusions can be highlighted from this thesis. First, comparing the performance of family health units vs. primary health care centres, FHUs seem to perform better on efficiency, quality and cost grounds. In comparison to PHCCs, FHUs allow for improvement in the processes of scheduling appointments and delivering physician's consultations. Additionally, the conversion of PHCC into FHUs suggests gains in the processes of scheduling appointments, of delivering physicians' and nurses' consultations, as well as in cost savings. These gains seem to be stronger for the conversion larger PHCC into FHU.

From all the obtained results, the final conclusion for the present study is that the ongoing Portuguese primary health care reform of implementing family health units leads to visible improvements on the accessibility, efficiency, quality and costs within this sector.

Finally, we make some suggestions on relevant future developments for the present work:

- Testing of the proposed models to all the Portuguese territory: in the present work we have studied a set of nineteen primary health care units (twelve primary health care centres and seven Family Health Units) from three municipalities of the Greater Lisbon sub-region: *Lisbon*, *Oeiras* and *Cascais*. It would be interesting to expand this analysis to all of the 347 PHCC and 141 FHUs spread all over in Portugal.
- Including different services and refining the modelling of operational processes: models could be improved by including a wider number of services (such as other types of consultations, e.g. oncology, psychiatry, and cardiology) and by modelling more detailed processes. However we should bear in mind that the more detailed a model is, the more difficult it becomes to run, and we should pay attention to computational times.
- Improving financial modelling: the present work only considered three costs estimates: the total costs, total costs with personnel and total costs with diagnosis tests and other treatments. More detailed cost information could allow for better cost estimates that could better inform on the impact of extending FHUs.
- Test new scenarios: once the models are built, one can easily analyse different scenarios in simulation models. For example, one could further test the impact of variations in demand and the impact of increasing human resources. It would be interesting to explore scenarios like: comparing FHUs under model payment A with FHUs with model payment B; and recent FHUs vs. old FHUs.

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Appendix 1

History of the Portuguese Primary Health Care

The first generation primary care centres was created in 1971 with the "*Gonçalves Ferreira Reform*" and with the Law 413/71. They were responsible not only for the prevention of certain contagious diseases through several vaccination campaigns but also for the assistance of more vulnerable groups like pregnant women and children. These centers coexisted with other institutions that provided health care attention to workers and their family - "*Serviços Médico-Sociais das Caixas de Previdência*" (Branco & Ramos 2001).

Around 1983, after the creation of the Portuguese NHS and the introduction of the general practitioner career, the second generation primary care centres were formed (97/83 Dispatch). . They were the result of the merge of the first generation primary care centres, the "*Serviços Médico-Sociais das Caixas de Previdência*" and the municipal hospitals (Branco & Ramos 2001; Gouveia et al. 2007a)

Despite some gains in the resource optimization and rationality, this whole model revealed to have a centralized management by the Regional Health Authorities, becoming impossible to answer the existent expectations and needs, and leading to an increasing number of unmotivated and dissatisfied professionals. (Branco and Ramos 2001).This way, a first attempt to change this situation was made in 1996 with the Alpha Project. This project was tried in some primary health care centres in Lisbon and consisted on the constitution of a multidisciplinary team with an agreed set of goals with the administration. Two years later, the Experimental Remunerative Regime (ERR) was created for general practitioners (Ministério da Saúde 1998). This reform tried to distinguish those GPs whose services were more team oriented and that had a higher performance in quality and accessibility in order to fight the increasing number of patients without a general practitioner, the inadequate timetables, long waiting times and excessive use of expensive technology and prescription of drugs (Direcção Geral de Saúde 2004). Doctor's remuneration was divided in two components - a fixed and a variable one. The first depended on the career, number of years worked and number of patients in their list and the second one depended on several elements like the number of house calls and the number of children and pregnant women followed.

In 1999, with the Law 157/99, an intention to create the third generation primary care centres emerged. It would not only increase the administrative and financial autonomy of these health care units but also make possible the creation of Family Health Units. However, with the 2002 elections, the government changed and this Law was revoke by the Law 60/2003. According to the government "the Law 157/99 didn't take into account the enormous diversity in the primary care centres' dimensions and didn't confer the referred autonomy" (Ministério da Saúde 2005).

In 2005, the government changed again as well as many anterior reforms. The Law 157/99 came into force again with the Law 88/2005.

Later in 2006, regulations were made in order to launch and implement de Family Health Units (FHU). These units should have organizational, functional and technical autonomy, based on multi-professional teams, formed by general practitioners, nurses, managers and other professionals in order to improve the accessibility and reconfigure the primary care centres (Gouveia et al. 2007a).

The last reform in the Portuguese primary health care took place in 2008. Primary health care centres groups (PHCG) were legislated, creating "public health services with administrative autonomy, formed by several functional units that cluster one ore more primary care centres, with the goal to ensure primary health care provision to the population of a certain geographic area" (Ministério da Saúde 2008).

PHCGs can be defined as "management units, formed by one or more primary care centres, integrated into the Regional Health Administration (RHA), responsible for the organization and integration of the several levels of primary health care and for the coordination with other community partners" (Ordem dos Enfermeiros 2007). The joint management of these units allows for a closer relation with patients, a gathering of resources and management structures that might allow for gains due to scale economies, and for gathering more epidemiological information that might inform policy.

The new map of PHCGs should be the result of the clustering between all structures and services of the primary care centres, being responsible for a resident population between 50.000 and 200.000.. It is planned to start working from the beginning of 2009.

Each PHCG is formed by five units: Family health units (FHU), Personalised Health Care Units (PHCU), Community Health Units (CHU), Public Health Units (PHU) and Assistance Shared Resources' Unit (ASRU). Each of these units is based on a multi-professional team with technical autonomy, acting in cooperation with the other units of the primary care centre and of the whole PHCG.

Thus, having the clinical governance centred in PHCGs, the correct organized framing that was missing for the successful implementation of FHUs becomes available (Campos 2008).

Appendix 2

Appointment Scheduling:

The following table contains the output values of the model, concerning the process of scheduling an appointment with the physician. It is important to notice that all these values were generated by the model not having information about the correspondent real data.

		Waiting time to see the receptionist (min.)	Number of days for a consultation with the physician	Percentage of use of Receptionists (%)
PHCC	PHCC Benfica	[3.95 ;4,81]	[29 ; 31]	[63,85 ; 66,19]
	PHCC Marchal Carmona	[4,39 ; 5,33]	[33 ; 35]	[28,12 ; 31,77]
	PHCC Carnide	[5,50 ; 6,11]	[14 ; 16]	[36,49 ; 38,42]
	PHCC Sete Rios	[7,80 ; 8,33]	[32 ; 38]	[64,17 ; 66,38]
	PHCC Linda-a-Velha	[6,82 ; 7,48]	[43 ; 48]	[33,09 ; 35,73]
	PHCC Algés	[3,04 ; 3,91]	[18 ; 21]	[41,39 ; 43,26]
	PHCC Oeiras	[7,79 ; 8,38]	[35 ; 39]	[54,27 ; 56,75]
	PHCC Paço de Arcos	[1,78 ; 2,45]	[47 ; 51]	[76,08 ; 78,29]
	PHCC Barcarena	[1,73 ; 2,43]	[16 ; 18]	[56,03 ; 59,40]
	PHCC Cascais	[8,16 ; 9,09]	[31 ; 34]	[82,29 ; 84,66]
	PHCC Estoril	[2,30 ; 3,44]	[26 ; 28]	[70,93 ; 73,09]
	PHCC Alvide	[4,39 ; 5,21]	[15 ; 18]	[56,7 ; 58,11]
	PHCC Alcabideche	[1,65 ; 2,77]	[17 ; 20]	[44,29 ; 47,28]
	Average PHCC	[4,56 ; 5,36]	[27 ; 30]	[54,43 ; 56,87]
FHU	FHU Rodrigues Migueis	[6,27 ; 7,82]	[12 ; 15]	[43,23 ; 44,88]
	FHU Tílias	[6,00 ; 6,97]	[13 ; 14]	[38,27 ; 40,02]
	FHU Dafundo	[1,10 ; 2,04]	[14 ; 16]	[54,27 ; 56,75]
	FHU Delta	[0,80 ; 1,59]	[14 ; 17]	[48,53 ; 50,01]
	FHU São Julião	[0,7 ; 1,32]	[15 ; 17]	[45,20 ; 47,58]
	FHU Marginal	[0.90 ; 1,63]	[15 ; 16]	[47,48 ; 49,37]
	Average FHU	[2,63 ; 3,56]	[14 ; 16]	[46,16 ; 48,10]

Appendix 3

General Practitioner's Consultations:

The following table contains the output values of the model related to physician's consultations. In this case, all values were generated by the model not having any information about the correspondent real data. The only exception is the number of consultations per physician, which real values are known.

		Number of Consultations per Physician	Time spent in the waiting room (min.)	Percentage of use of Physicians
PHCC	PHCC Benfica	[3836 ; 3958]	[23,38 ; 29,74]	[77,81 ; 78,38]
	PHCC Marchal Carmona	[3836 ; 3867]	[43,27 ;49,76]	[74,72 ; 75,81]
	PHCC Carnide	[4318 ; 4366]	[41,89 ; 45,83]	[82,31 ; 86,43]
	PHCC Sete Rios	[3868 ; 3906]	[83,97 ; 94,23]	[85,28 ; 87,84]
	PHCC Linda-a-Velha	[5244 ; 5307]	[85,40 ; 103,10]	[82,58 ; 87,01]
	PHCC Algés	[5372 ; 5459]	[26,76 ; 32,00]	[89,24 ; 93,5]
	PHCC Oeiras	[3912 ; 3995]	[87,53 ; 94,62]	[90,57 ; 95,32]
	PHCC Paço de Arcos	[3989 ; 4092]	[64,52 ; 71,89]	[91,62 ; 95,35]
	PHCC Barcarena	[4339 ; 4422]	[50,92 ; 53,12]	[84,18 ; 86,77]
	PHCC Cascais	[3908 ; 4020]	[49,86 ; 53,05]	[87,65 ; 89,14]
	PHCC Estoril	[3860 ; 3945]	[84,49 ; 98,07]	[80,56 ; 83,63]
	PHCC Alvide	[3754 ; 3955]	[19,85 ; 24,56]	[71,79 ; 79,34]
	PHCC Alcabideche	[3860 ; 3887]	[26,70 ; 29,62]	[72,79 ; 76,01]
	Average PHCC	[4161 ; 4244]	[52,96 ; 59,97]	[81,62 ; 84,96]
FHU	FHU Rodrigues Migueis	[4946 ; 5040]	[34,65 ; 39,50]	[91,21 ; 91,82]
	FHU Tílias	[4031 ; 4198]	[22,70 ; 30,65]	[78,04 ; 82,61]
	FHU Dafundo	[4151 ; 4205]	[45,45 ; 51,76]	[82,53 ; 82, 89]
	FHU Delta	[4267 ; 4322]	[29,94 ; 35,22]	[73,84 ; 79,55]
	FHU São Julião	[4504 ; 4574]	[42,08 ; 47,95]	[89,12 ; 91,35]
	FHU Marginal	[4412 ; 4509]	[24,20 ; 27,83]	[73,12 ; 75,72]
	Average FHU	[4385 ; 4641]	[27,34 ; 38,82]	[81,31 ; 83,99]

Appendix 4

Acute/Urgent Cases:

The following table contains the output values of the model related to acute/urgent consultations. All values presented were generated by the model not having any information about the correspondent real data.

		Waiting time for an acute/urgent consultation (min.)
PHCC	PHCC Benfica	[5,77 ; 6,84]
	PHCC Marchal Carmona	[2,11 ; 2,15]
	PHCC Carnide	[13,17 ; 15,72]
	PHCC Sete Rios	[13,59 ; 15,12]
	PHCC Linda-a-Velha	[4,98 ; 6,16]
	PHCC Algés	-
	PHCC Oeiras	[47,35 ; 52,52]
	PHCC Paço de Arcos	-
	PHCC Barcarena	[11,29 ; 13,65]
	PHCC Cascais	[9,89 ; 11,35]
	PHCC Estoril	-
	PHCC Alvide	-
	PHCC Alcabideche	-
	Average PHCC	[13,52 ; 15,44]
FHU	FHU Rodrigues Migueis	[8,17 ; 10, 89]
	FHU Tílias	[10,19 ; 11,84]
	FHU Dafundo	[11,85 ; 13,31]
	FHU Delta	[9,77 ; 10,63]
	FHU São Julião	[11,98 ; 12,54]
	FHU Marginal	[16,14 ; 18,98]
	Average FHU	[11,35 ; 13,03]

Appendix 5

Nursing Care:

The following table contains the output values of the model related to nursing consultations. In this case, all values were generated by the model not having any information about the correspondent real data. The only exception is the number of consultations per nurse, which real values are known.

		Number of nursing consultations per nurse	Time spent in the waiting room for Type 1 [5] consultation (min.)	Time spent in the waiting room for Type 2 consultation (min.)	Percentage of use of Nurses (%)
PHCC	PHCC Benfica	[2731 ; 2813]	[4,47 ; 6,78]	[5,15 ; 6,30]	[42,06 ; 45,83]
	PHCC Marchal Carmona	[2428 ; 2440]	[15,07 ; 17,89]	[10,46 ; 12,58]	[72,86 ; 74,20]
	PHCC Carnide	[1875 ; 1899]	[3,25 ; 4,85]	[5,67 ; 7,86]	[53,41 ; 58,79]
	PHCC Sete Rios	[3167 ; 3283]	[12,11 ; 13,62]	[13,45 ; 14,22]	[65,89 ; 66,33]
	PHCC Linda-a-Velha	[2415 ; 2542]	[5,83 ; 6,55]	[6,87 ; 7,89]	[56,76 ; 58,22]
	PHCC Algés	[2731 ; 2874]	[3,94 ; 4,58]	[10,94 ; 12,51]	[69,06 ; 72,66]
	PHCC Oeiras	[1956 ; 2042]	[2,26 ; 3,45]	[2,75 ; 3,66]	[48,36 ; 52,87]
	PHCC Paço de Arcos	[1584 ; 1636]	[3,77 ; 4,73]	[8,63 ; 9,58]	[43,01 ; 45,89]
	PHCC Barcarena	[1661 ; 1731]	[3,96 ; 4,52]	[3,31 ; 4,55]	[44,88 ; 45,71]
	PHCC Cascais	[3333 ; 3427]	[2,15 ; 3,81]	[8,29 ; 9,72]	[74,13 ; 77;92]
	PHCC Estoril	[3140 ; 3236]	[2,00 ; 3,16]	[30,87 ; 32,17]	[73,55 ; 77,94]
	PHCC Alvide	[2297 ; 2395]	[6,39 ; 7,20]	[11,39 ; 12,88]	[58,37 ; 60,02]
	PHCC Alcabideche	[2578 ; 2697]	[9,06 ;10,73]	[5,53 ; 7,92]	[67,31 ; 70,33]
	Average PHCC	[2453 ; 2462]	[5,71 ; 7,07]	[9,49 ; 10,91]	[57,67 ; 60,52]
FHU	FHU Rodrigues Migueis	[2157 ; 2186]	[4,08 ; 5,66]	[4,04 ; 5,55]	[55,96 ; 59,31]
	FHU Tílias	[2312 ; 2408]	[5,24 ; 6,78]	[5,08 ; 5,93]	[60,21 ; 62,01]
	FHU Dafundo	[2181 ; 2295]	[2,23 ; 3,78]	[1,25 ; 3,05]	[50,56 ; 56,31]
	FHU Delta	[2106 ; 2150]	[2,34 ; 3,77]	[10,14 ; 12,49]	[58,87 ; 61,11]
	FHU São Julião	[3224 ; 3571]	[1,65 ;3,41]	[11,31 ; 13,09]	[68,33 ; 72,76]
	FHU Marginal	[1430 ; 1576]	[1,84 ; 2,56]	[1,34 ; 3,65]	[74,78 ; 76,81]
	Average FHU	[2235 ; 2364]	[2,89 ; 4,32]	[5,53 ; 7,29]	[61,45 ; 64,72]

[5] Nursing Cares were divided in two different types:

- Type 1: Diabetes, Child or Maternal Consultation
- Type 2: Consultation for Vaccination or other type of treatments

Appendix 6

Costs:

The total costs associated to each primary health care provider are presented in the above table. These total costs are the result of the sum of the costs associated with the personnel and the costs associated with diagnosis tests and other treatments. The values of each of these elements are presented in the following tables.

		Total Costs (€)	
Benfica	PHCC Benfica	[7.738.933 ; 7.900.164]	[2.021.361 ; 2.085.812]
	PHCC Marchal Carmona		[3.001.159 ; 3.057.179]
	PHCC Carnide		[1.365.562 ; 1.380.740]
	FHU Rodrigues Migueis		[1.350.851 ; 1.376.433]
Sete Rios	PHCC Sete Rios	[8.438.721 ; 8.556.590]	[7.337.684 ; 7.409.988]
	FHU Tílias		[1.101.037 ; 1.146.602]
Carnaxide	PHCC Linda-a-Velha	[8.764.357 ; 8.883.014]	[4.421.476 ; 4.474.914]
	PHCC Algés		[2.831.254 ; 2.876.945]
	FHU Dafundo		[1.511.627 ; 1.531.155]
Oeiras	PHCC Oeiras	[11.639.538 ; 12.489.696]	[4.123.564 ; 4.210.782]
	PHCC Paço de Arcos		[2.973.481 ; 3.666.180]
	PHCC Barcarena		[1.143.379 ; 1.165.143]
	FHU Delta		[1.553.825 ; 1.573.807]
	FHU São Julião		[1.845.289 ; 1.873.784]
Cascais	PHCC Cascais	[11.323.794 ; 13.163.011]	[4.119.032 ; 4.237.870]
	PHCC Estoril		[3.254.646 ; 3.326.265]
	PHCC Alvide		[1.779.469 ; 1.876.066]
	PHCC Alcabideche		[1.627.533 ; 1.670.405]
	FHU Marginal		[2.008.114 ; 2.052.405]

		Costs with Personnel (€)		Costs with Drugs and Complementary Diagnosis/Treatment Exams (€)	
Benfica	PHCC Benfica	[2.120.728 ; 2.164.648]	[517.806 ; 534.316]	[5.618.205 ; 5.735.516]	[1.503.555 ; 1.551.496]
	PHCC Marchal Carmona		[768.798 ; 783.148]		[2.232.361 ; 2.274.031]
	PHCC Carnide		[349.812 ; 353.700]		[1.015.750 ; 1.027.040]
	FHU Rodrigues Migueis		[484.312 ; 493.484]		[866.539 ; 882.949]
Sete Rios	PHCC Sete Rios	[2.274.420 ; 2.309.278]	[1.879.672 ; 1.898.194]	[6.164.301 ; 6.247.312]	[5.458.012 ; 5.511.794]
	FHU Tílias		[394.748 ; 411.084]		[706.289 ; 735.518]
Carnaxide	PHCC Linda-a-Velha	[2.399.864 ; 2.432.258]	[1.132.636 ; 1.146.325]	[6.364.493 ; 6.457.756]	[3.288.840 ; 3.328.589]
	PHCC Algés		[725.274 ; 736.978]		[2.105.980 ; 2.139.967]
	FHU Dafundo		[541.954 ; 548.955]		[969.673 ; 982.200]
Oeiras	PHCC Oeiras	[3.483.288 ; 3.552.331]	[1.056.321 ; 1.078.663]	[8.756.250 ; 8.937.365]	[3.067.243 ; 3.132.119]
	PHCC Paço de Arcos		[915.408 ; 939.154]		[2.658.073 ; 2.727.026]
	PHCC Barcarena		[292.896 ; 298.471]		[850.483 ; 866.672]
	FHU Delta		[557.083 ; 564.247]		[996.742 ; 1.009.560]
	FHU São Julião		[661.580 ; 671.796]		[1.183.709 ; 1.201.988]
Cascais	PHCC Cascais	[3.481.866 ; 3.573.872]	[1.055.160 ; 1.085.602]	[8.218.928 ; 9.589.139]	[3.063.872 ; 3.152.268]
	PHCC Estoril		[833.733 ; 852.079]		[2.420.913 ; 2.474.186]
	PHCC Alvide		[456.097 ; 480.586]		[1.324.372 ; 1.395.480]
	PHCC Alcabideche		[416.920 ; 419.769]		[1.210.613 ; 1.250.636]
	FHU Marginal		[719.956 ; 735.836]		[1.288.158 ; 1.316.569]

Appendix 7

Appointment Scheduling:

The following values correspond to the model's results for the performance indicators in the appointment scheduling process. All these values were exclusively created by the model.

		Benfica		Sete Rios	Carnaxide		Oeiras			Cascais			
		PHCC Benfica	PHCC Marchal Carmona	PHCC Sete Rios	PHCC Linda-a-Velha	PHCC Algés	PHCC Oeiras	PHCC Paço de Arcos	PHCC Barcarena	PHCC Cascais	PHCC Estoril	PHCC Alvide	PHCC Alcabideche
Setting Up Consultations	Initial waiting time (min.)	4,43	4,85	8,06	7,26	3,47	8,09	2,12	2,08	8,59	2,95	4,78	2,21
	Variation in waiting time (%)	-17,23	-72,1	-87,59	-78,3	4	-60,1	-43,88	-76,32	-65,91	-46,44	-79,36	-29,84
	Initial number of days for a consultation with the physician (days)	30	34	36	45	20	37	29	17	33	27	17	19
	Variation in number of days for a consultation with the Physician (%)	-65,01	-54,5	-54,2	-67,06	-46,03	-58,21	-67,38	-38,19	-53,89	-44,51	-2,78	-15,88

Appendix 8

General Practitioner's Consultations:

The following values correspond to the model's results for the performance indicators for the general practitioner's consultations process. All these values were exclusively created by the model.

		Benfica		Sete Rios	Carnaxide		Oeiras			Cascais			
		PHCC Benfica	PHCC Marchal Carmona	PHCC Sete Rios	PHCC Linda-a-Velha	PHCC Algés	PHCC Oeiras	PHCC Paço de Arcos	PHCC Barcarena	PHCC Cascais	PHCC Estoril	PHCC Alvide	PHCC Alcabideche
Ambulatory	Initial total number of ambulatory consultations	38860	58425	139921	84496	54210	79280	68629	21945	79260	62480	34695	30992
	Variation in total number of ambulatory consultations (%)	32,36	17,92	16,78	-19,23	-4,75	18,12	8,14	17,75	17,8	7,07	17,805	7,85
	Initial total number of ambulatory consultations per Physician	3886	3895	4882	5281	5421	3964	4037	4389	3963	3905	3855	3874
	Variation in total number of ambulatory consultations per Physician (%)	32,36	17,92	16,73	-19,23	-4,75	18,12	8,14	17,75	17,8	7,07	17,81	7,85
	Initial time spent in the waiting room (min.)	26,56	46,52	89,1	94,25	29,38	91,08	68,21	52,02	51,68	91,28	22,21	28,16
	Variation in time spent in the waiting room (%)	51,86	-12,74	-49,5	-48,29	36,57	-64,75	-31,41	-23,27	-40,67	-48,71	103,61	72,48
	Initial percentage of use of Physicians (%)	78,09	75,27	86,56	84,79	91,37	92,95	93,49	85,48	88,39	82,09	65,57	74,4
	Variation in percentage of use of Physicians (%)	17,71	5,88	4,26	-2,4	0,63	-16,2	-7,48	7,56	-11,89	0,78	37,99	11,22

Appendix 9

Acute/Urgent Cases:

The following values correspond to the model's results for the performance indicators in the acute/urgent process. All these values were exclusively created by the model.

		Benfica		Sete Rios	Carnaxide		Oeiras			Cascais			
		PHCC Benfica	PHCC Marchal Carmona	PHCC Sete Rios	PHCC Linda-a-Velha	PHCC Algés	PHCC Oeiras	PHCC Paço de Arcos	PHCC Barcarena	PHCC Cascais	PHCC Estoril	PHCC Alvide	PHCC Alcabideche
Acute / Emergency Cases	Initial number of acute cases	8059	11966	20074	8462	'	22753	'	5525	11298	'	'	'
	Variation in number of acute cases	-64,78	-8,57	33,55	37,25	-	-34,19	-	-74,29	33,03	-	-	-
	Initial waiting time for acute cases	6,34	2,13	14,32	5,56	-	49,94	-	12,47	10,62	-	-	-
	Variation in waiting time for acute cases (%)	-85,72	434,53	-3,22	127,01	-	-78,93	-	-5,96	-1,31	-	-	-

Nursing Care:

The following values correspond to the model's results for the performance indicators for nursing consultations. All these values were exclusively created by the model.

		Benfica		Sete Rios	Carnaxide		Oeiras			Cascais			
		PHCC Benfica	PHCC Marchal Carmona	PHCC Sete Rios	PHCC Linda-a-Velha	PHCC Algés	PHCC Oeiras	PHCC Paço de Arcos	PHCC Barcarena	PHCC Cascais	PHCC Estoril	PHCC Alvide	PHCC Alcabideche
Nursing Consultations	Initial total number of nursing consultations	16634	24312	77400	39652	27726	31989	29007	8480	54080	44630	23463	21101
	Variation in total number of nursing consultations (%)	98,04	26,02	5,29	-9,7	17,62	24,11	48,6	94,25	26,6	-13,97	-13,17	-15,15
	Initial total number of nursing consultations per Nurse	2772	2431	3225	2478	2773	1999	1813	1696	3380	3188	2346	2638
	Variation in total number of nursing consultations per Nurse (%)	98,04	26,02	5,29	-9,7	17,62	24,11	48,6	94,25	26,6	-13,97	-13,17	-15,15
	Initial time spent in the waiting room for Type 1 consultation (min.)	5,63	16,48	12,87	6,19	4,26	2,86	4,25	4,24	2,98	2,58	6,79	38,40
	Variation in time spent in the waiting room for Type 1 consultation (%)	-19,05	-81,7	-80,67	-52,02	-25,43	36,47	-36,75	-27,43	37,86	4,67	-65,41	-70,08
	Initial time spent in the waiting room for Type 2 consultation (min.)	5,73	11,52	13,84	7,38	11,73	3,21	9,11	3,93	9,01	31,52	12,14	6,73
	Variation in time spent in the waiting room for Type 2 (%)	148,94	-41,92	-11,93	71,57	15,76	194,35	-21,5	250,88	3,95	-93,23	0.46	-69,44
	Initial percentage of use of Nurses (%)	43,95	73,53	66,11	57,49	70,86	50,62	44,45	25,30	76,03	75,75	59,19	68,82
	Variation in percentage of use of Nurses (%)	51,02	-22,89	6,7	-16,71	-6,8	19,41	39,43	162,05	-20,53	-29,51	15,65	-22,41

Appendix 10

Costs:

The following values correspond to the model's results for the performance indicators regarding the costs. All these values were exclusively created by the model.

		Benfica		Sete Rios	Carnaxide		Oeiras			Cascais			
		PHCC Benfica	PHCC Marchal Carmona	PHCC Sete Rios	PHCC Linda-a-Velha	PHCC Algés	PHCC Oeiras	PHCC Paço de Arcos	PHCC Barcarena	PHCC Cascais	PHCC Estoril	PHCC Alvide	PHCC Alcabideche
Costs	Initial total costs (€)	2.053.586 €	3.029.169 €	7.437.836 €	4.448.195 €	2.854.099 €	4.167.173 €	3.619.831 €	1.154.260 €	4.178.451 €	3.290.456 €	1.828.267 €	1.648.969 €
	Variation in total costs (%)	-13,86	-12,20	-81,65	43,19	-52,12	-7,70	-31,83	63,36	-13,63	-5,06	-45,36	-4,86
	Initial costs with Personnel (€)	526.061 €	775.973 €	1.888.933 €	1.139.481 €	731.126 €	1.067.492 €	927.281 €	295.683 €	1.070.381 €	842.906 €	468.341 €	418.345 €
	Variation in costs with Personnel (%)	20,56	22,88	-74,10	100,40	-32,99	29,18	-4,59	128,64	20,88	32,88	-23,53	34,45
	Initial costs with Drugs and Complementary Diagnosis/Treatment Exams (€)	1.527.525 €	2.253.196 €	5.548.903 €	3.308.714 €	2.122.973 €	3.099.681 €	2.692.550 €	858.577 €	3.108.070 €	2.447.550 €	1.359.926 €	1.230.624 €
	Variation in costs with Drugs and Complementary Diagnosis/Treatment Exams (%)	-25,72	-24,28	-84,23	23,48	-58,71	-20,40	-41,21	40,88	-25,52	-18,12	-52,88	-18,22