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TRANSFERRING INDUSTRIAL CONCEPTS TO HEALTHCARE SERVICE NETWORK MANAGEMENT

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Abstract
In European countries healthcare systems are organized as territorial networks of services, managed by a hierarchical organization either central or regional. In any country, incidence of healthcare system cost on GNP is going to be explosive. So, new techniques for performance evaluation of services and for cost control must be applied. However, a careful management of both the offered services and the necessary costs must be done, to respect the persons' basic needs and rights. The healthcare service management till now adopted is centred on the service itself, and based first on the desire of doctors to have the most advanced machines, second on the goal of speeding the interventions on patients, to reduce the costs of holding. Thus, wrong effects result. The application of industrial management methods, looking at the specific service and user, allows a more effective impact on the care efficiency and its costs. This paper outlines the results obtained by two projects developed by the authors.

Keywords:
Healthcare service; Networked systems; Industrial management

1 INTRODUCTION

1.1 Why transfer industrial methods to managing healthcare systems?

Looking at the majority of European countries, the healthcare (**HC**) system is characterized by a common organization [1] [2]. The basic unit is a Local Healthcare Agency (**LHA**), referred to as an area whose population is usually corresponding to a *province*. All LHAs located in a same region depend on the regional government, which coordinates the HC services in terms of political plans and attribution of the annual budget. In case of the Italian situation, the charitable system is prevalently public; it covers all the population with contributions of workers and employers (40%), from the general taxation (35%) and with contributions of private citizen and assurances (25%). Regard to funding instalments, each regional administration subdivides funds among the LHAs depending on their resident populations [3].
During the last decade, the growing ageing of population is making the number of "end-users" of healthcare services larger and larger; the explosion of the offer of diagnostic and therapeutic technologies, more and more sophisticated, enlarges costs; the increasing demand for health (well being) transform environmental and relational discomforts into needs for additional healthcare services. This implies that careful interventions must be designed so as to manage these deep changes: a "re-engineering" of the national HC service organization must, on one side, to keep as low as possible the HC service costs, but on the other, to assure to every person a satisfactory level of good health.
The most important actions to be taken are the following: first, to design and apply a monitoring system that could allow identification of Key Performance Indicators (**KPI**); second, to clearly specify which types of management actions should be applied, in which form and time.
This paper presents an outline of the main results obtained by the research group chaired by the authors in two parallel projects, one oriented to identify meaningful KPIs [1], the other aiming at defining the main lines of a territorial HC management [2].

1.2 Basic elements of a HC territorial system

The management of HC services is done at the level of each LHA by the managerial chief through interactions with the network of HC service centres located in the LHA territory. Such a network includes several different types of service types, namely: the "hospital service", which is here considered (for sake of simplicity) to include all diagnostic, chirurgical and rehabilitation activities to be performed in a complex well equipped centre for health; the "local consulting", "health status testing" centres, etc., that are intermediate services to which patients are addressed for better diagnosis, but from which they could be addressed to hospitals; and the "family doctor" and "specialists", that are input services, to which patient refer for diagnosis and prescription of therapy. Then, a territorial network of HC service centres is at disposal of a distribution of users (the citizens living in the LHA area).
Each person is a potential "end-user" of the HC system, that is a "patient" who wants to maintain his/her health status by interacting with the operators and professionals of the HC system. This interaction occurs in terms of "demand for health" and "offer of health maintenance service". However, the demand is identified only from the interaction of two agents: the patient, asking for service without a complete knowledge of what to ask, and the doctor, trying to supply the best service, with the need to acquire a sufficient knowledge on the person's demand, in the same time. So, both the demand and the offer of care are the result of a <u>cooperative interaction</u> of the two agents, being the *demand* identified by the first phase of the interaction, i.e., the diagnosis phase, while the *offer* is identified by both the diagnosis and the therapy phases [4] [5].

1.3 Basic elements of a LHA management

The management of the LHA services is usually performed at two complementary levels:

a. At the level of an individual HC service, each HC professional (e.g., doctor, specialist, etc.) states specific addressing instruction to any patient – "prescriptions" – thus giving him/her indications of which other HC service should be contacted;

b. At the level of the HC network, the LHA manager aims at monitoring the patients' flows over the network and to plan the service centres capacities.

These preliminary elements of LHA management suggest to find first analogies between the HC sector and the industrial systems. However a care attention must be paid to analyze also the differences between one and the other ambient.

Table 1: Analogies between production and health care.

Production system	*Healthcare system*
Operating cycle	Care protocol
Product maintenance	Patient's care
Client-supplier	Patient-doctor

Table 2: Differences between production and health care.

Production system	*Healthcare system*
Product = system output	No analogy
No analogy	Patient's health status
Client-supplier negotiation	Patient-doctor cooperation

Said table show that two main differences must be taken into account:

i. The patient asks for help to maintain his/her own health status, i.e. it does not exist any object ("product") to be processed;
ii. It must be activated a cooperation between the patient (client) and the doctor (supplier) to help each other to identify the patient's health status.

1.4 Why search for analogies between industrial and HC systems management?

Considering above two tables, it could be doubtful to search for analogies between the two sectors: production and health care. On the contrary, there are two main reasons for studying potential analogies as well as evident differences.
First, the two sectors present a number of common concepts, such as the following: supplier (of services), client (calling for service); resources (used for providing services); protocols (to provide services), etc. However, in the healthcare sector, it does not exist an effective managerial culture based on clear managerial and costing methods. This is the main reason why, as above mentioned, the costs to provide healthcare services are too high.
Second, owing to a lack of managerial culture, it appears a wrong use and abuse of industrial management procedures and packages to the HC service planning and control: usually, production management software with rough adaptation to the care system.
So, from the management point of view, the real needs of the health care sector that can be satisfied by industrial management reasoning, can be expressed by the following questions:

1st. How to be able to select clear KPIs such as to have an effective monitoring of the system performance, and identification of the most critical services?

2nd. How to be able to select management strategies which should be applied in the most convenient and efficient organization of the HC professionals such as to detail their control tasks and responsibilities?

3rd. How to be able to estimate the costs required by any management strategy, and to decide cost savings without degradation of the care?

2 MODELLING PATIENT'S CALL TO UNDERSTAND HC MANAGEMENT OF INDIVIDUALS

In order to answer to the first question, It is necessary to have a clear understanding of how the care service required by a patient can behave, in practice.

A flow-chart can describe the most usual steps a patient must run when approaching the healthcare system. The input step is the interaction between patient and doctor, for a medical examination. Said interaction implies a number of phases: first, patient examination; then, potential addressing of patient either to an health status testing center or to a specialist (or both); then, the doctor's confirmation of a diagnosis; then, the therapy prescription; finally, the patient addressing either to a hospital, or to home.

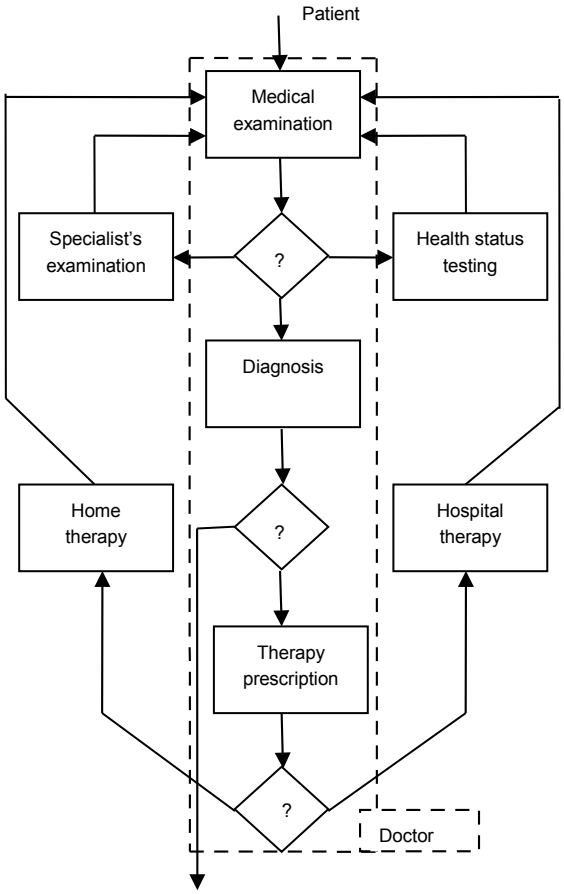

Figure 1. Conceptual scheme of the patient interactions with the HC system

The analogy with a flow-chart simply describing how to handle a part to be manufactured at a production center is quite evident (see the following Figure 2).

This simple descriptions suggests that, as in the production planning/scheduling [6], a Gantt diagram representation can be applied to describe the "***patient's path***" in the HC system, as in Figure 3.

This Gant diagram gives clear suggestions about a number of critical aspects of the patient-to-HC system interaction:

A. The <u>number of "contacts"</u> between the patient and a HC professional, either doctor, specialist, laboratory or hospital, makes evidence of the uncertainty in specifying the care protocol (similar to the low ability of the production planner in declaring the expected product quality and selecting the operational cycle).

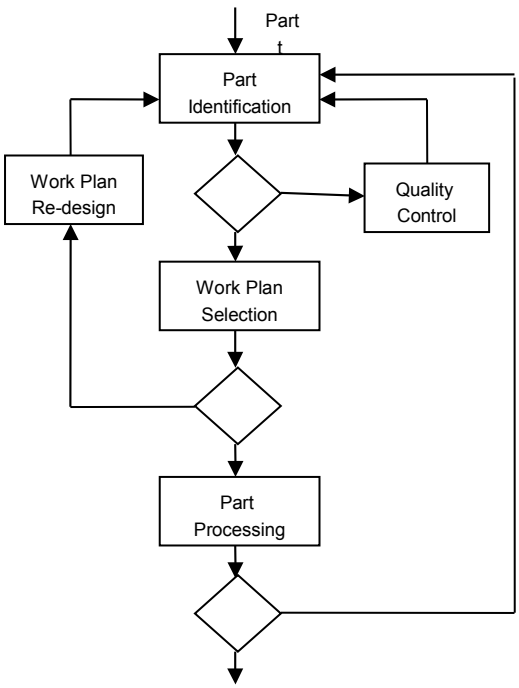

Figure 2. Simple scheme of the part handling at a manufacturing center.

B. The time spent from the first contact with the family doctor and the return to home, restored, measures the time wasted in queues (similar to the *makespan* to complete a product).

C. The maximum time period spent between two consecutive contacts shows the longest delay in front of a care service, then recognized as a critical service (similar to the *bottleneck* phase in production).

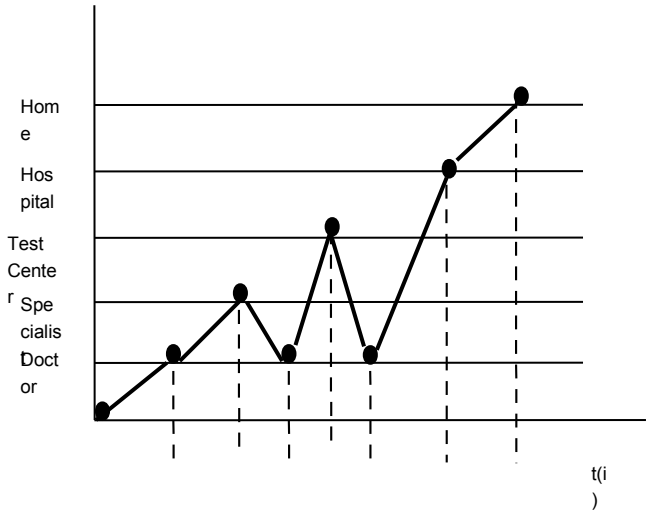

Figure 3. Simple Gantt diagram showing a typical path of a patient in the healthcare system

The illustration of some patients paths is sufficient to make clear some critical points of a number of HC service professionals and centers to a LHA manager.
But one has to take account of the dimension of the LHA service centers network. Referring to a small Italian LHA as the one of the Asti province, the number of potential patients ranges on 200.000, with about 200 family doctor, 50 specialists, 50 child specialists, 10 health status testing centres, and 3 hospitals.
Now, the problem is: how to apply a reasonable strategy to monitoring individual patients and related paths in the HC system? Owing to the number of patients in a LHA, this is still open...

3 MODELLING PATIENTS' FLOWS TO RECOGNIZE USEFUL KPIs

The analysis of individual patient's paths along the HC service centers network can give clear suggestions to an LHA manager only if the monitored paths include contacts with service centers already identified as potentially critical. A same usefulness of this monitoring approach occurs in case of patients forced to move on longer and longer paths, even in case of non serious illness.

However, in general, the LHA manager's approach to the HC system performance analysis needs to apply a monitoring strategy that allows to estimate performance measures at the system level.

3.1 How to recognize the most attractive service centers.

A LHA manager needs to have at disposal a model describing the patient's choices over the network of service centres, in order to be able to modify the services accordingly. To this aim, a useful approach – based on industrial experience – consists of the estimation of the patients flows over the network of service centres by formally modelling the preferences of patients and their movements over the service network: that's the gravity models' approach [7].
The patients' flows analysis can be done by searching for:

(a) the main characters of the "sources" from which the demands for health are generated, namely distribution of the population, places, activities, main transportation directions, etc.;
(b) an estimation of the LHA capacity to supply services through its centres, depending on the amount of resources there allocated;
(c) an estimation of the capability of centres to attract patients, driven by the service capacity planned at the centres themselves.

The patients flows that can be computed by applying a gravity model will allow the analyst to recognize, on one hand, how patients evaluate the service centres, their personnel and supplied service activity; on the other hand, to estimate how patients usually follow suggestions of LHA personnel, as doctors, specialists, and lab professionals.
So, some KPIs estimating the performance of a HC center, considered as one of the "nodes" of the HC service network, are the following:
(a) the "users basin", i.e. the geographic area and the number of urban sites whose population utilizes the considered center [8];
(b) the center "accessibility", i.e. the percentage of patients with movement difficulty who use the considered center, compared to the others;
(c) the center "attractiveness", i.e. the relative capacity of the center to attract patients, compared to the other similar service centers;
(d) the "resource utilization" per service type.
Each one of the above KPIs can give significant suggestion to the LHA manager. The first two offer a clear characterization of the service center in terms of position in the LHA territory; the third one describes the strength of the service offer, as well as its professional level as recognized by patients; the fourth one shows the center efficiency.
Based on these KPIs, a LHA manager can have evident suggestions for his crucial task of installing the funding received by regional government.

3.2 How to recognize the most important cost generators

As suggested by the considered KPIs, the costs to provide the HC services over a LHA territory depend on three main reasons:

i. The type and quantity of the demand for care that's originated from the population;

ii. The type and utilization of resources and technologies allocated at the HC centers;

iii. The professional ability and the attention to patients characterizing the sanitary operators (doctors and nurses*, in primis*).

For a correct cost evaluation, a first aspect to be considered is if it exists a right balance between the demand for care and the resources allocation, in terms of both machineries and centers sites on the territory. A second aspect, often not sufficiently taken into account, is to estimate the impact of the professional ability and attention to patients at the various HC centers: indeed, this could give rise to a significant reduction of costs.

These two considerations makes clear the necessity of a definite management strategy able to use the monitored or estimated KPIs and to recognize which control-planning actions could be applied in terms of either service modifications or incentives attributions to professionals or patients education.

Actual experience in monitoring LHA management approaches shows that the real problem is that, in general, LHA managers have unclear vision of how to use the KPI information and to transform them into an organic strategy. So, even in this case, industrial concepts applied in planning and controlling production and service plants can give some help.

A useful idea is to integrate into a common management scheme the actions and reactions that are done by the LHA manager, the professionals operating in the HC service centers, and the patients reaction, namely:

i. planning decisions adopted by the LHA network manager;

ii. decisions to assure the quality level of services and the service centre attractiveness, made by the service providers;

iii. decisions to choose the most credible provider and the most accessible service centre, done by the patients.

By using this classification of decision types, a model of the LHA management can be stated in terms of a block diagram (and related planning/control actions) directly derived from the industrial application of control theory – as represented in Figure 4. This figure gives a clear view of the application of concepts developed in the frame of Control Theory and frequently applied in industrial management [9], to the healthcare sector. The application indeed describes the interactions among the three agents of a LHA in terms of respective decisions concerning either the planning and local control of the offered services, or the choice of some service centres, and the service providers there operating.

According to the block diagram of Figure 4, the LHA manager has the task of programming the service capacities of the HTA centers, thus assuring a planned attractiveness and a sufficient quality level. To this aim, the LHA manager can use information concerning the population distribution in the LHA territory, and evaluate the expected flows of persons towards the centers (e.g. by gravity models).

Considering a local service center, the center manager has to transform the centralized plans into time-by-time controls. On one hand, it has to assure that the attractiveness of its own center be as high as possible, through a careful management of the incoming patients' flows (e.g., through scheduling of arrivals and services, by possibly applying industrial scheduling tools [10]). On the other, it has to monitor the offered quality (e.g., by Quality Control tools [11]). Both actions should be designed – and applied – by taking into account that the local manager's decision is a typical feedback control, driven by information both on the currently offered service types and levels, and on the number of patients who decided to use this same service center.

The utilization of a service center by a patient depends on two main considerations (as in case of a "client" of an industrial service): first, the possibility of a fast utilization of the service; second, the a-priori evaluation of the service quality, usually based on the "credibility" of the provider and the information previously received on the efficiency of the center personnel. These two considerations could also be collected by the local service managers, e.g. by analyzing a number of patient's paths (se Figure 3).

By considering the management tasks according to the integrated view offered by the scheme of Figure 4, both the LHA manager and the local centers responsible and professionals can realize the most convenient actions to be done, as well as their related costs. The consideration paid to the patients potential choices makes evident how a right selection of investments and of local service modifications often do not induce costs increase not reflecting in service improvement.

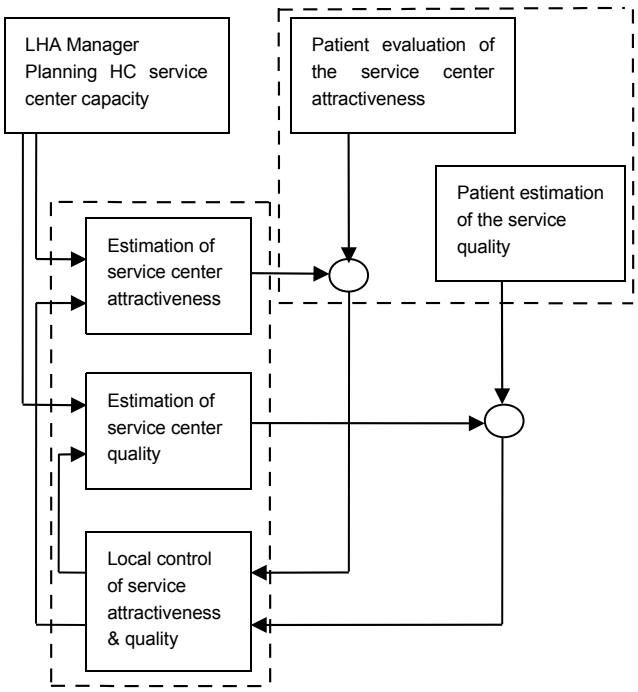

Figure 4. A conceptual scheme of the integrated management of a LHA (see [12]).

4 APPLICATION EXPERIENCE: AN OUTLINE

The LHA analysis and management approach has been developed and tested on the patients data that are collected and stored in the data base of the Local Sanitary Agency of the province of Asti, North Italy.

The most relevant work has been required to translate the official data into an operational data base, on which analyses could be done in reasonable time. Indeed, in front of a population of about 220.000 citizens, the number of prescriptions of family doctors and specialists in a year was about 2,5 million. To these prescriptions,

corresponding service actions done either by testing labs, or ambulatories or hospitals have also been analyzed.

Some statistics can give an outline of the results till now obtained.

The main characters of the population, that can be give suggestions about the type and amount of the demand for care, are illustrated by the following Figures 5 and 6.

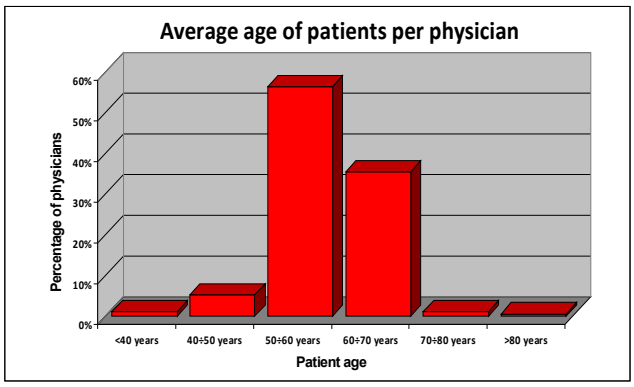

Figure 5. Patients age distributions.

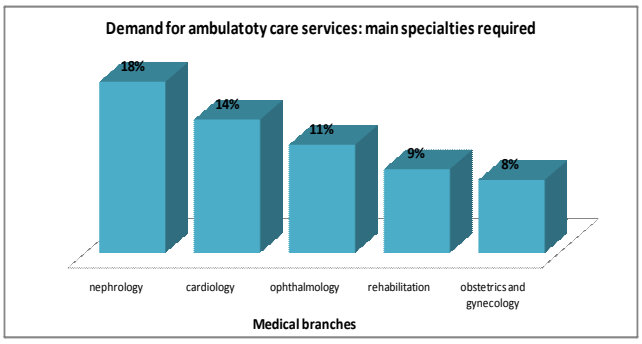

Figure 6. Main medical branches among cares required by patients.

To such a population, the service provided by family doctors can be evaluated by the Figures 7 and 8.

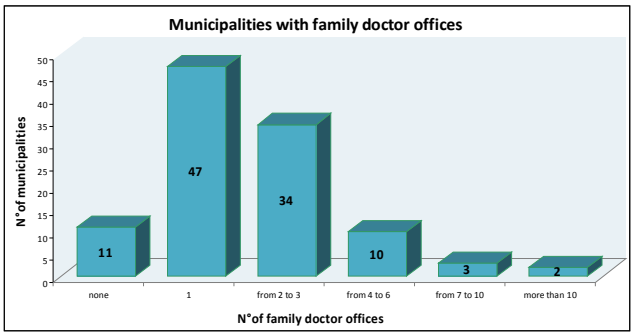

Figure 7. Distributions of doctors offices over municipalities.

A specific analysis has also been done on the services provided by the public and private hospitals in the Asti province: the scope has been to see if there are difference among the differently equipped hospitals. To this aim, HC services have been classified as therapeutic procedures (TP), diagnostic procedures (DP) and examination (V), and the percentages of HC services provided by the ambulatory centers of the LHA of Asti to its patients have been computed, as shown in the following Table 3. It can be recognized that no evident difference among the centers exists, thus showing the necessity of a better addressing of patients as well as of actions to promote the professionals recognitions by patients.

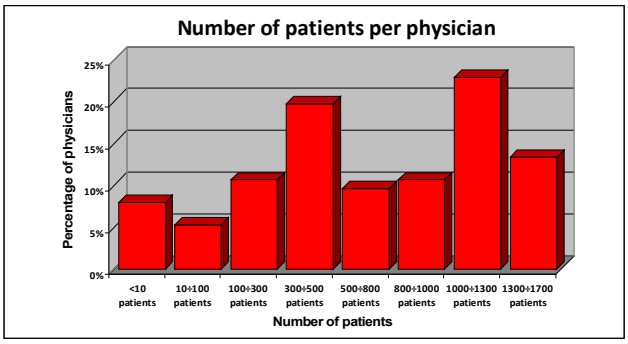

Figure 8. Distribution of the number of patients per family doctor.

Table 3. Main HC service types provided by ambulatories.

comune	centro	codistit	PC	PD	V
Asti	poliambulatorio via orfanotrofio	000359	21,14%	40,70%	38,16%
S.Damiano	poliambulatorio (s. damiano)	000365	12,30%	87,70%	0,00%
Asti	poliambulatorio cardinal massaia	000670	23,80%	49,16%	27,04%
Nizza	poliambulatorio vallebelbo	000672	20,46%	43,50%	36,04%
Asti	poliambualtorio territoriale	001130	20,69%	42,80%	36,51%
Asti	poliambulatorio casa di cure s.giuseppe	500075	8,34%	81,80%	9,86%
Asti	centro diagnostico cernaia	500077	11,64%	39,54%	48,82%

Another significant parameter to evaluate if the population has a clear recognition of the professionals quality is given by the "population mobility", measured by the percentages of patients using HC services within the LHA or outside the LHA where they stay. This measure is evidenced by the following Figure 9.

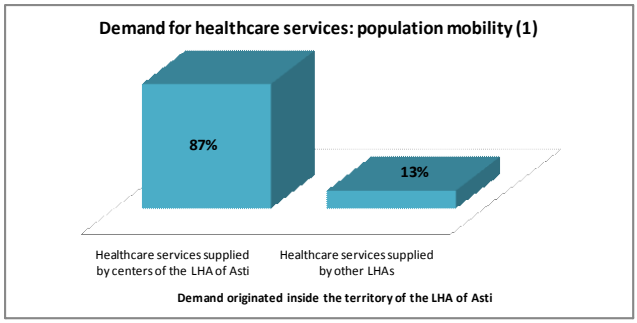

Figure 9. Percentage of care provided by LHA centers for residential patients and patients coming from outside LHA.

Having at disposal a set of figures and statistical tables of the type illustrated above, a LHA manager can derive significant indications about either the most effective or the most critical care services, centers, professionals, as well as indirect but clear information concerning the patient satisfaction [13] [14].

5 CONCLUSIONS

The paper has the scope to outline the main results of two research projects developed by the authors in the last three years. The goal of identifying some "measures" of the performance of a Local Healthcare Agency – the basic HC service organization in a number of countries – has been the objective of said projects, whose validation has been done by applying the analysis method to the patients' data of the LHA of the Asti province.

By analyzing the results, some performance evaluation suggestions can be derived and then used as management criteria. So, it appears useful to estimate data on the population, such as to have suggestions about the demand for care. Moreover, a description of the main directions of patients towards HC centers give indications about the attractiveness of the centers themselves: this reflects into suggestions on how to attribute funding, as well as how to enforce or reduce the resources.

The present status of the research development has given a sufficient set of KPIs. The on-going evolution is directed to link the KPIs to management criteria, in such a way to provide to LHA managers two types of tools: on one hand, tools to evaluate if the funding installments to HC Centers are such to offer services well appreciated by patients; on the other, tools to decide how to modify the service characteristics of a center such to compress costs without affecting the patients' expected service quality.

6 ACKNOWLEDGMENTS

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