Monitoring the pharmaceuticals demand flow in public hospitals with the BAM paradigm

[1]Dimitrios Folinas, [3]Dimitrios Aidonis
[1]Department of Logistics, Technological Educational Institute of Central Macedonia
Kanellopoulou 2, 60100, Greece, dfolinas@gmail.com, daidonis77@gmail.com

[2]Anestis Fotiadis,
[2]Entertainment Management Department, I-Shou University, No.1, Sec. 1, Syuecheng Rd., Dashu District, Kaohsiung City 84001, Taiwan. E-mail: anesfot@gmail.com

Abstract
The main objective of this paper is the development of an approach for demand handling of the pharmaceuticals in a hospital based on the business activity monitoring (BAM) paradigm. After identifying the main characteristics and challenges of the pharmaceuticals' demand the authors argue that the BAM combined with the modeling of demand management process and the identification of the corresponding events will allow a better analysis of the historical data and provide a better sense of demand. The deployment of the proposed approach will give decision makers the ability to respond accurately to the various internal and external events and overall to meet the needs of the health care organizational entity in terms of the pharmaceuticals planning.

Keywords: Demand, Pharmaceutical, Public Hospitals, Health Informatics

Introduction

Pharmaceutical expenditure and public health costs are major issues for all governments. In most countries expenditures of pharmaceuticals has been gradually increased and most governmental policies are trying to find successful strategies to constrain the price of pharmaceuticals. Moreover, in several countries prescription cost is covered by the public insurance.

On the other hand the economic crisis have forced governments to take actions since in most of the problematic countries social insurance funds were already on insurmountable levels (Korol, 2013). Controlling the price of pharmaceuticals has been the main focus of policy efforts to decrease healthcare expenditure (Lambrelli & O'Donnell, 2011). But physicians and patients are very conscious in their prescription and consumption since compensation system provides little incentives related to the prices of pharmaceuticals.

Today, public hospitals generate and process on a daily-basis a tremendously large volume of data deriving from various business activities and processes, such as procurement, manufacturing, retail, marketing, sales and distribution. Such data is often processed by an extensive array of computer-based applications (Health Information Systems, HIS) and has a significant importance to the business entities towards effective and on-time decision making. However, a main drawback of these systems is that they frequently suffer from a lack of contextualized information that is reliable, accurate and

delivered 'on time' to have a purposeful meaning to the decision-makers. The value of information grows exponentially with the addition of each domain of data, information or knowledge that is integrated correctly with it (Hayes, 2001).

Furthermore, during the last two decades governments have made great investments to Health Care Information systems in order to improve cost-effectiveness, quality and accessibility of health care (Bertelsen & Nøhr, 2005; Chiasson & Davidson, 2004; Jamal, McKenzie, & Clark, 2009). Current economic conditions and the new strategies impose the use of a business activity monitoring information management system which will promote operational cooperation between health units, regional health authorities and central services. This system will enable an operational command over personnel matters, financial management, budgets, patients handling and management and will satisfy the requirement for homogeneity of all sizes measurable business units that manage health and integrated management of the patients. As such sizes are operational materials, suppliers, pharmaceuticals, medical expenses, management of patients, the administration of the estate of hospitals and accounting management functions.

The main objective of this study is the development of an approach for demand handling of the pharmaceuticals in a public hospital based on the business activity monitoring (BAM) paradigm. The proposed approach includes specific steps for the identification and understanding of the critical events that arise in the examined sector based on its constraints.

The paper is organized as follows. The next section identifies the main characteristics of the pharmaceuticals demand in the public hospitals. It sets the challenges and requirements that influence the examined procedure. After modeling the pharmaceuticals demand flow and identifying the main constraints the main functionalities of the BAM approach are incorporated into the demand flow so as to form a step-by-step approach for monitoring the pharmaceuticals demand in public hospitals. Finally, both the expected benefits and challenges of the application of the proposed approach are presented and discussed.

Pharmaceutical demand and business activity monitoring systems

There are two key concepts that are studied in this paper; first, the pharmaceutical demand process, and second, the business activity monitoring systems. Authors argue that it is crucial to identify the objectives, requirements and challenges of the pharmaceutical demand in order to design an effective framework that exploits the best practices and abilities of the BAM paradigm.

Pharmaceutical demand

The role of medicine is a critical success factor in the provision of health services. Medicines contributed to the increase in life time, improve of the quality of life and the disappearance of diseases (previously considered deadly). Demographic changes, macro-economic pressures, the emergence of new diseases, new therapies and new therapeutic standards, as well as, the increased expectations of patients contributed to a rapid increase of health-cost in the decade

of 90's. That's why the cost of healthcare has a long-term upward trend.

The increase of pharmaceutical expenditure is associated with the raised drug consumption and it has been affected by socioeconomic and demographic factors. Specifically, it is the aging of the population and the new discoveries in pharmaceutical science - which contribute to the circulation of new active substances- that lead to the increased pharmaceutical expenditure. Pharmaceutical demand is affected by many different variables. One of the main determinants of pharmaceutical demand is the structure of drugs' cost sharing (Lexchin & Grootendorst, 2004). Liu, Yang, and Hsieh (2011), as well as,Okunade and Murthy (2002) identified also the age, sex, unhealthy consumption, technological upgrade and drug class, that might modify pharmaceutical demand between different countries. Gaskin et al., (2006) for example proved that there are differences between black or hispanic and white patients in USA. In the literature there are several studies as well (an indicative list include Gaskin, Briesacher, Limcangco, & Brigantti, 2006 and Jimenez-Rubio & Hernandez-Quevedo, 2010).

It is understood that the efforts to reduce costs, must be accompanied with an efficient use of resources. An obvious solution is the application of ICT tools that give the top management of the hospitals the ability to have all the necessary information to make better predictions, more efficient and effective use of resources and to provide better health services (Bose, 2003; Sokolova & Fernández-Caballero, 2009).

Specifically, these systems can help managers to make a more reliable forecasting of the pharmaceutical demand. Forecasting can help experts make a strategic decision (Cheng, Wang, & Li, 2008; Štěpnička, Cortez, Donate, & Štěpničková, 2013) since the design of decision support system is gradually more significant for prescribing, health performance measures, etc. If the level of accuracy is not in the right level a number of major consequences will occur on the health care supply chain. Moreover, during the financial crisis, forecasting is becoming more and more valuable for the public health units growth and survival. Some researchers indicated that managers use only their working experiences as the main forecasting method but this created various financial problems in some health units that overestimated the pharmaceutical demand (McCarthy, Davis, Golicic, & Mentzer, 2006). Therefore, the improvement on demand forecasting process is a necessity. Syntetos, Nikolopoulos and Boylan (2010), as well as, Syntetos, et al., (2009) argue that the pharmaceutical demand forecasting is a very demanding and challenging process and also in practice it doesn't take into consideration the critical and unexpected events of the market as well as the various constraints that characterize the examined sector.

BAM

During the last decades a number of practices, approaches, methods and systems are proposed in the market for supporting the decision making process. First, numerous enterprise information systems, such as Enterprise Resource Planning, Customer Relationship Management systems, etc. and / or best-of-breed business information systems (such as Warehouse Management Systems, etc. provide static reports and insight to transactional data, which was enough for line-level

managers, but decision-makers wanted information in a more summarized fashion in order to perform strategic analyses from huge amounts of data that expanded in a wide time range and from multiple sources. Another approach is the Data Warehousing (DW) and the Online Analytical Processing (OLAP). The advantage of the DW is that users can query data from across the enterprise. Using OLAP technique, analysts create complex, multidimensional analyses and deliver to business users meaningful insights that might not be readily apparent (Devlin, 1997; Dobbs, Stone, & Abbott, 2002; Kaplan & Norton, 1992; Ma, Chou, & Yen, 2000; Smith, 2001). The above software applications, technologies and analytical methodologies, which perform data analysis, constitute the Business Intelligence (BI) domain. BI exploits all the software applications, practices, technologies and analytical methodologies, which perform data analysis and provides real-time visibility and access to pertinent information, wherever its location, for each participant, to support enterprise competitiveness (Corral, Griffin, & Jennex, 2005). This paper proposes a new advance of BI paradigm, the real-time BI or Business Activity Monitoring (BAM) systems. BAM systems combine data collection with process and workflow management capabilities to monitor streaming data from operational systems to detect exceptions or critical business events. BAM lets companies visualize business events and KPI's in real time and in a format that's actionable. It gives enterprises insight into their business processes and systems through the use of dashboards and alerts.

For example, notifications are sent to managers when certain critical events have occurred, such as inventory stock being under the tolerance limit on a shelf. These notifications appear on managers' desktop computers or through mobile workers' handheld devices, pagers and cell phones. By enabling users to view, analyze and act on visually represented data, businesses can make rapid, informed decisions and better manage their performance. Based on the above, this paper presents and analyses a conceptual framework, which constitutes a new approach for BI in enterprises.
There are many research initiatives that proposed a framework for a BAM system in various business domains and/or functional areas (Table 1).

Table 1: Research initiatives that proposed a framework of BAM paradigm

Authors / Year	Business Domain / Functional area
(Xu, Wijesooriya, Wang, & Beydoun, 2011)	Enterprises / Business performance.
(Han, Choi, Kang, & Lee, 2010)	
(D. Kang, Lee, Kim, & Lee, 2009)	Enterprises / Business performance.
(Bajo, de Paz, de Paz, & Corchado, 2009; Broda & Clugage, 2006)	Enterprises / Decisions making process.
(Han & Kang, 2007)	Enterprises / Operations optimization.
(Janiesch, Matzner, & Müller, 2012)	Manufacturing companies / Production
(B. Kang, Kim, & Kang, 2012)	Enterprises / Business processes optimization.
(Folinas, 2007)	Enterprises / Business processes optimization.

(Folinas, Bochtis, & Sorensen, 2011)	Enterprises / Business processes optimization. Enterprises / Operations optimization.

In this study the application of the BAM paradigm for the effective and efficient handling of pharmaceuticals' demand in public hospitals is explored. A systematic approach is presented identifying the required steps. These steps (which are emerged from the literature review) can form a framework for the monitoring of the health care processes and the effective and reliable procurement decisions. It will also integrate the data that are produced by the above processes so as to handle them in a common manner. Data can be produced by many sources (both from inside and outside of the organization) as presented in the Table 2:

Table 2: External and internal data of the pharmaceuticals demand

External data	Inner data
Medicines price, **Ministerial decisions,** **Legislative decisions,** **Unexpected events (such as viruses, etc.),** **Medical protocols,** **etc.**	Hospital administrative decisions, Doctors opinion, Pharmacist opinion, Patients' particularities (e.g. demographic and clinical characteristics, financial status, insurance fees, etc.), Warehouse shortage, Warehouse stocks, etc.

The proposed approach will integrate the above data and based on predefined rules will identify the critical events of the business and hospital environment according to the various constraints of the examined demand flow. The deployment of the proposed step-by-step approach can give decision makers a more accurate supply response that reflects more precisely demand and improved planning across functions to meet the objectives of a health care organizational entity.

Monitoring the pharmaceuticals demand in public hospitals

The pharmaceuticals demand flow in public hospitals includes three main roles: 1) Patients, who act as the pharmaceuticals demand initiators, 2) Physicians, who make the decisions, since they are the representatives of knowledge for a hospital about a patient (Ellingsen & Monteiro, 2003), and 3) Demand handlers, who handle the decisions in terms of pharmaceuticals demand that have taken by the Physicians (Figure 1). The following figure depicts schematically the pharmaceuticals demand in public hospitals that presents the interaction among the three main roles.

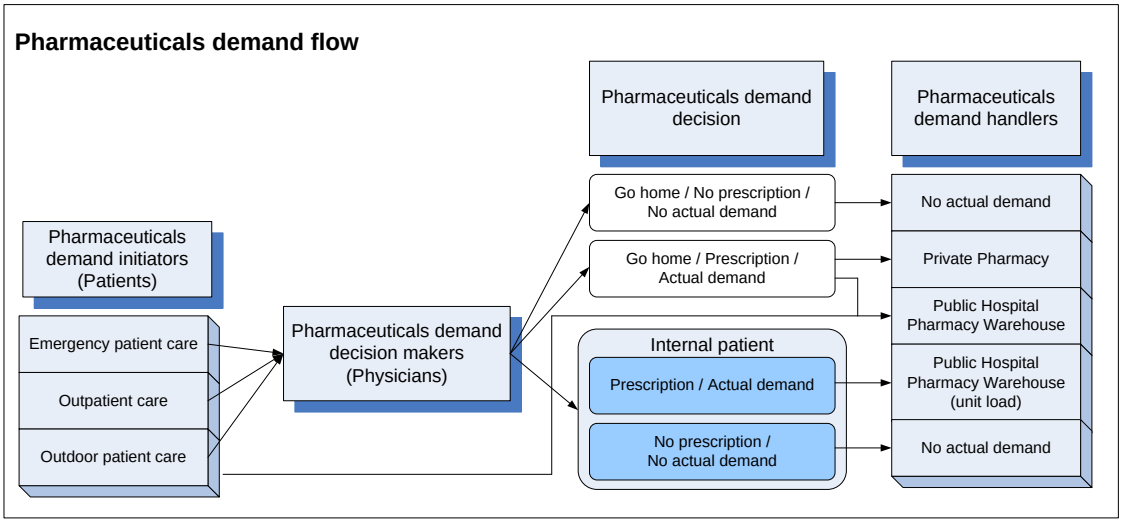

Figure 1: Monitoring the pharmaceuticals demand in public hospitals

Specifically,

Emergency patient care

Patients of the Emergency Care Unit can make an unplanned visit in a hospital any time of the day. Medical staff receives them into an appropriate area and depending of the seriousness of the case (first triage) patients wait at the waiting area (Constantinides & Barrett, 2012). The patients' personal information is then recorded in the integrated system of the hospital and depending on their individual circumstances they will pay a fee. Doctors examine the patient and depending on the case they may:

- Ask the patient to go home with or without medication (hospital pharmacy or private pharmacies).
- Ask the patient to be hospitalized in short-stay care unit with or without medication (hospital pharmacy).
- Ask the patient to be hospitalized at one of the clinics making an import with or without medication (hospital pharmacy).
- Ask the patient to return for a medical review at a later time in the Outpatient Care Unit with or without medication (hospital pharmacy or private pharmacies).

Outpatient Care Unit

Patients arriving at the Outpatient Care Unit either for reviewing purposes or because they believe that something is wrong with their health. They make a phone call at the hospital and they can set up an appointment from 07.00 to 15.00. Their details are recorded in the integrated information system of the hospital and they will pay a fee. Doctors examine the patient and depending on the case they may:

- Ask the patient to go home with or without medication (hospital pharmacy or private pharmacies).
- Ask the patient to be hospitalized at one of the clinics making an import with or without medication (hospital pharmacy).
- Ask the patient to return for a medical review at a later time in the Outpatient Care Unit with or without medication (hospital pharmacy or private pharmacies).

Outdoor patient care
The Outpatient Care Unit patient arrives at the hospital attending either the regular or the emergency surgeries after receiving the instruction from another physician. For example, one can visit a health center (primary care) and the doctor can send him to the hospital (secondary care) for further tests. Depending on where the Outpatient Care Unit patient is brought from one of the above-mentioned procedures is followed. Then they are recorded in the integrated information system of the hospital and depending on the case they pay the appropriate fee. Also in the category of Outpatient Care Unit patients are the ones who go directly to the hospital pharmacy and take drugs regardless of whether or not are going to be examined there (welfare receivers etc.).

Pharmaceutical demand decision makers
Doctors, depending on the condition of each patient, determine the drugs that will be given to them. Of course there are many constrains mainly concerning which drugs can be found in the pharmacy and what instructions have been given for each prescription by the ministry and the government. Lately DRGs and ICD-10 were introduced on Public Hospitals in Greece and they can affect health system since IT supporting systems and coding practices are important for public health reorganization (Lewis, Harvey, Dartnell, & Sheph, 2004; Robinson & Shepheard, 2004). The prescription is placed via a Pan-Hellenic computerized information system (www.e-syntagografisi.gr); the same applies for the referral for employment, outside the hospital, examinations which is also using a nationwide computerized information system (www.e-diagnosis.gr). Within the hospital it is done through its own information system.

Pharmaceutical demand decision
Doctors' decisions affect pharmaceutical demand decision. What interests us at this stage is whether there is a creation of demand for medication and how that product distribution is taking place. In the case where it is decided by the doctors that they there is no need for medication then one could suggest that pharmaceutical consumption will not be created. If it is decided to let the patient leave the hospital with the prescription of medication, then demand is created which can be satisfied either through a private pharmacy or by the hospital pharmacy. In this case, patients obtain the entire package of the prescribed medication. If the patients are referred either to the short-stay unit or to any other clinic for treatment then they are considered to be inpatients. In this case, the demand is for the supply of the pill pack and not of the entire package and it is done through the integrated information system.

Pharmaceutical demand handlers
Pharmaceutical demand handlers are responsible for meeting the raised demand. In the case of private pharmacies, patients get their medication by using the prescription given to them by their physicians. In the case of a hospital pharmacy there is a difference in the handling between indoor and outdoor patients. In the case of outpatients, the entire package is given irrespectively if all the pills in the pack will be required or not. In the case of inpatients, they are placed into an electronic allocation plan of beds where the doctors electronically notify the type of medication that each patient will follow; that way a pill distribution rather than a packaging one

is taking place, so that pills will not be wasted. Automatically the electronic warehouse of the hospital gets updated and by next day the required quantities of pills are sent at each clinic. At each clinic there is a local decentralized warehouse where there is a safety limit; this limit is again controlled by the integrated information system.

Pharmaceuticals demand constraints

In the suggested conceptual framework for the monitoring of the pharmaceuticals demand in public hospitals a key part is the identification and the management of constraints as depicted in Figure 2. The development of a model is not originate by the objectives of designers or managements, but throughout a continuing process of negotiation between multiple actors and their technological choices (Constantinides & Barrett, 2006).

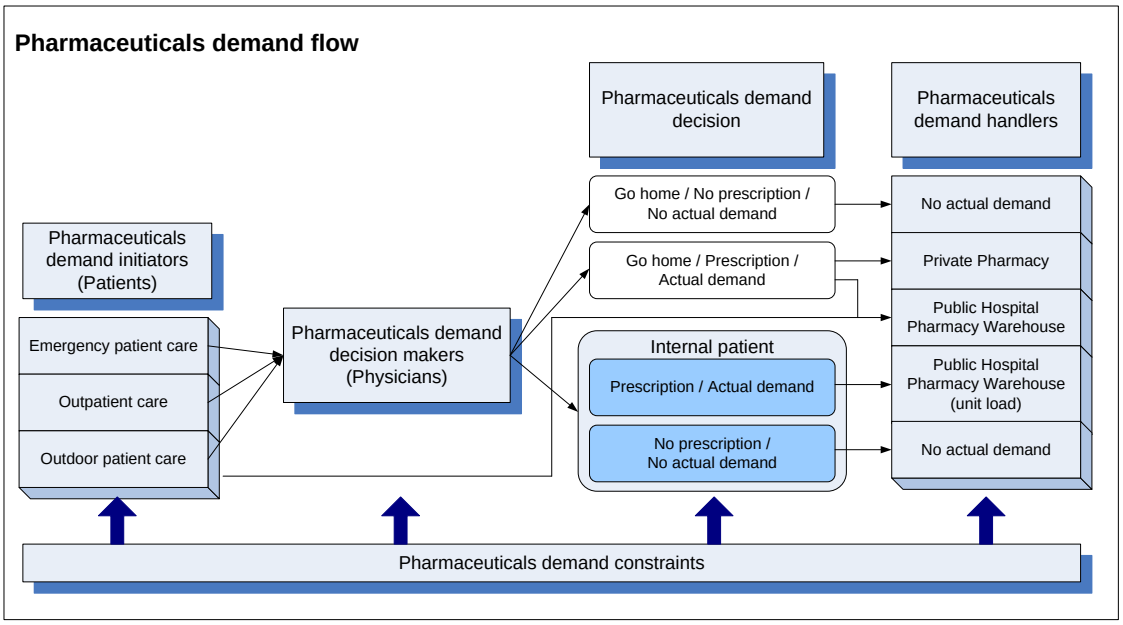

Figure 2: M monitoring of the pharmaceuticals demand in public hospitals based on the constraints

These constraints can influence the demand; they even postpone or call off an order. For example, a Ministerial decision may exclude a specific pharmaceutical for the list of eligible drugs. The following figure illustrates the basic groups of constraints (Figure 3).

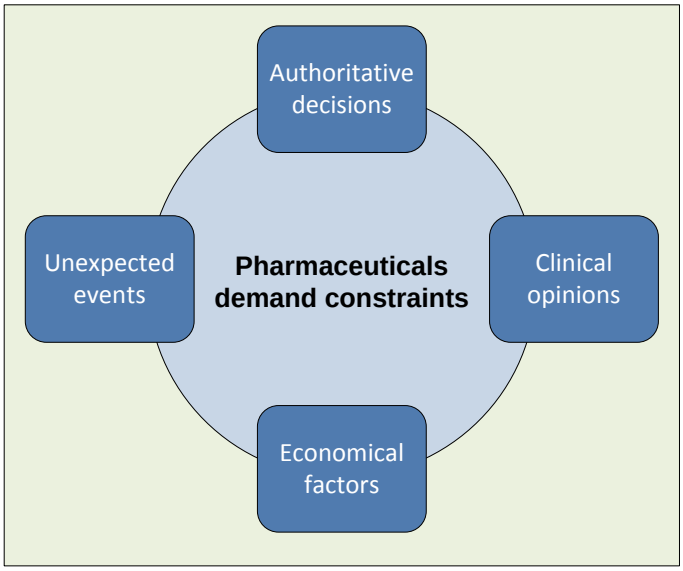

Figure 3: Basic constraints of the pharmaceuticals demand in public hospitals

Authoritative decisions are decisions made by Public Authorities or other policy makers that influence strategically the pharmaceuticals demand in public hospitals and public health care. These are Ministerial decisions (e.g. medical protocols, etc.), Legislative decisions, or decisions by the top management of a public hospital. Usually they have a long-term vision and thus they are of high importance.

On the other hand clinical decisions include all those that are being significantly affected by the opinions of doctors and the pharmacists related with patients' particularities. For example when a patient arrives at the hospital the corresponding doctor having knowledge about his/her condition decides to provide a specific description. This opinion is constrained by the above authoritative decisions. Furthermore, there are times when doctors ask pharmacists' opinion related with the availability of the product either on the hospital's warehouse or the market.

There are also economical factors and specifically first, the pricing policies of medical products, secondly the insurance fees and benefits (since there are different insurance paradigms from different insurance categories), and thirdly the preferences of patients in accordance of their financial status. These factors are especially critical during economic slowdown periods.

Finally, there are unexpected events that affect drastically the demand flow. Events such as the appearance of new dangerous viruses or contagious diseases, crisis periods (nutrition, food, economic, etc.) and even of the emergence of natural disasters can be considered as common examples in this category. All the above events are challenging and difficult to handle since there are limited precaution and preventive actions.

All the above constraints are strongly interrelated although they have different causations, preconditions, importance and time horizon.

Pharmaceuticals demand monitoring with BAM paradigm

After incorporating the various constraints the main concept and philosophy of a typical BAM system (based on previous researches as presented in Table1) can be applied in the targeted products' demand flow including a number of steps as illustrated in the next figure.

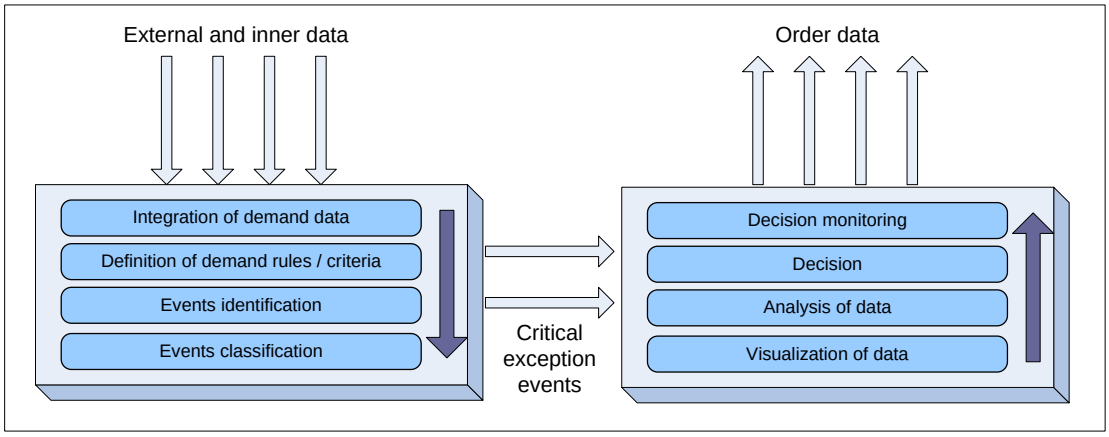

Figure 4: A conceptual framework for demand monitoring

The integration of the data is the first step in the application of the BAM paradigm. The main aim is to remove ambiguity and ensure that there can be mutual understanding in terms of pharmaceutical demand by all the stakeholders. Therefore, common data definitions, clinical concepts and terminologies, as well as, coding and classifications, are required in order to support the collection of consistent and comparable data on the demand status of the community and health services (including performance measurement). The majority of public hospitals in EU countries and all the hospitals in Greece have a hospital pharmacy which is part of the hospital. This is mainly because of the will of their managers to have central administration and decision-making regarding logistics processes (e.g. same storage rooms / warehouses, same labeling, common warehouse facilities, etc.).

The next step includes the definition of specific and straightforward rules ranging from simple rules and criteria to complex analytic scenarios / business activities that refer to the demand of pharmaceuticals in public hospitals. These rules can be derived by monitoring and analyzing historical data and/or significant (in terms of the demand) external or inner events. An event is just a signal that the internal and/or external data has changed; there are several events that can affect pharmaceutical demand. For example, last year the Greek Ministry of Health decided that in public hospitals 30% of the medicines should be originals and 70% generics. It is worth stating here that the originals are more expensive and before that there were not any regulation. Another example can be considered the apprehension of an epidemic; for example last autumn the Greek government has procured a big quality of specialized medicines to confront with the bird flu which actually proved to be overestimated.

Most applications already generate events, if only for their own internal use. The main objective is the development and tracking of models in order to quickly perform real-time trend analysis on up-to-

date information. For example in a public hospital when the level of drugs goes under a specific level, hospital information system informs the pharmacist to make a new order (e.g. to come up against an unpredictable epidemic and/or disease).

Moreover, it includes the monitoring of various activities by looking for metrics or information that meets specific conditions in the business environment. When a rule finds an exception condition in an activity, it triggers an event and sends the appropriate contextual information to the decision makers notifying them of the fact. Thus, the event identification step aims to ensure that critical issues that affect the demand of pharmaceuticals are processed without delay. Then it visualizes the combined information in business views and provides appropriate decision / action to take, according to predefined rules or settings. Finally, a performance measurement system evaluating and success of the quantities and qualities of the procured pharmaceuticals can be established. This will ensure the reliability of the decisions of the managers.

The following figure (Figure 5) illustrates the final architecture of the proposed framework based on the above steps.

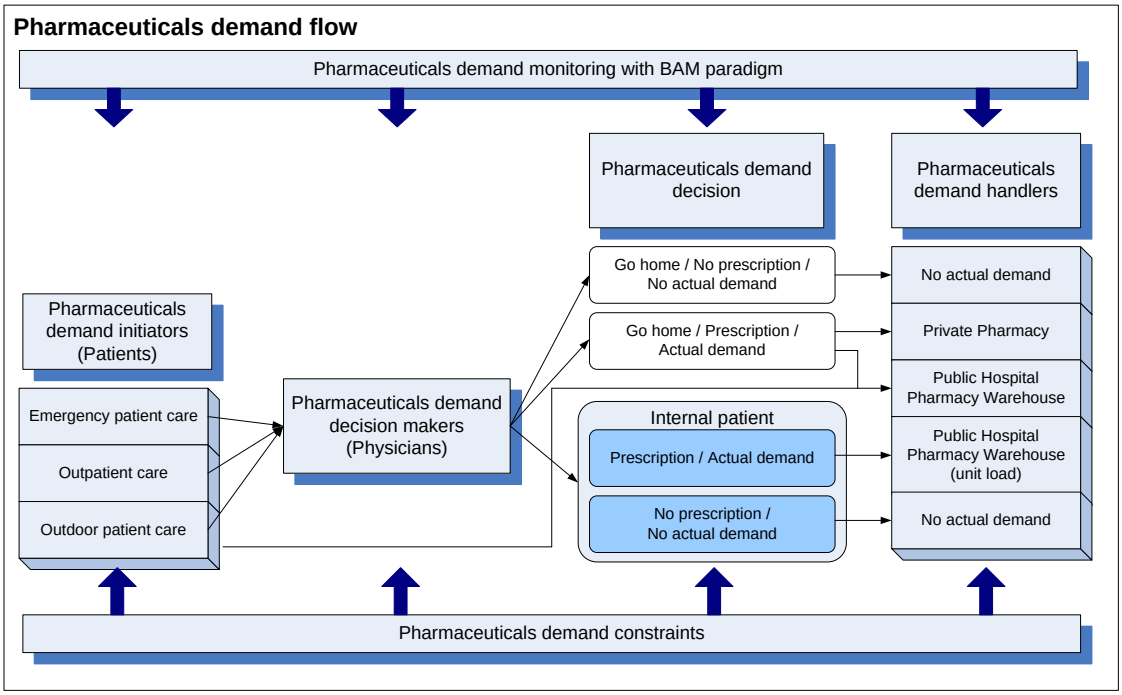

Figure 5: Monitoring of the pharmaceuticals demand in public hospitals based on the constraints and the BAM paradigm

One example of a wrong estimated demand procedure and an example case of the deployment of the proposed framework was during the influenza vaccination (September 2009) for the flue A (H1N1) in Greece. Due to the panic atmosphere that was created by the death of 144 people in Asia, as was as, the announcement of "red alert level 6" managers of the public hospitals ordered a high-volume of vaccines to the Department of Suppliers in Ministry of Health. Therefore, a very high order was made to the pharmaceutical industry. According to the framework this problem could have been considered not only as an

authoritative decision but at the same time as an unexpected event, a clinical opinion and also according to the economical downhill of the national economy. Authors argue that all the framework's constraints could have been considered as well. Therefore, all the required data could have been integrated and specific events could have been established. If the Ministry of Health had a clear view of the analysis of data and events it could have made a more accurate and realistic decision or it could have made partially the orders.

Conclusions

For an effective and integrated public healthcare care system there is a need for an effective and efficient management of the pharmaceuticals demand. The usage of a Business Intelligence System can be a reliable solution for the above needs. The adoption of a BIS, as well as, the conformity to international standards for pharmaceuticals'' coding schemes will give the managers the opportunity to make better decisions for an effectual handling of the pharmaceutical demand. These system must be as simple as possible so at the same time physicians would have no problem on retrieving and producing information's for patients (Sørby & Nytrø, 2005).

In this paper a BIS framework based on the Business activity monitoring (BAM) paradigm was presented and analyzed. The proposed framework aims to provide contextual information to top management on more reliable demand forecasts of the pharmaceuticals in every public hospital regardless the information system that the hospital uses. Several variables can affect pharmaceutical demand and they should be included in a forecasting instrument which can assist hospital experts to make significant strategic decisions (Cheng et al., 2008; Leggat, 2008; Lin et al., 2009; Štěpnička et al., 2013).

The proposed framework includes specific steps for the identification and understanding of the critical events that arise in the examined sector based on its constraints and it gives the opportunity to the users to consult with a computerized system during the decisions process as other researches supported (Cheng et al., 2008; Escobar-Rodríguez, Monge-Lozano, Romero-Alonso, & Bolívar-Raya, 2012; Lin et al., 2009; Sokolova & Fernández-Caballero, 2009; Štěpnička et al., 2013) In the projected framework the engaged groups for pharmaceuticals demand flow are patients, physicians and demand handlers, who deal with pharmaceutical demand constrains such as authoritative decisions, clinical opinions, economical factors and unexpected events. External and internal data is integrated with the use of a typical BAM system and they create a performance measurement system able to evaluate quantities and qualities of the procured pharmaceuticals that will ensure the reliability of the decisions of the managers.

Authors argued that this framework will exploit the information wealth that the hospitals maintain in their information systems and databases. They will give managers to form strategic plans for a systematic monitoring of critical events in the business environment regarding the pharmaceuticals' demand and also support their performance measurement.

The ultimate aim is the optimization of inventory management in order to achieve what is for the top priority for the public health sector

the minimization of wastes and high inventory levels, which in turn encumber the national budget and the national insurance system. Therefore, authors will concentrate in the future to the development of practices and approaches to support the application of BIS in this key sector.

References

Bajo, J., de Paz, J. F., de Paz, Y., & Corchado, J. M. 2009, Integrating case-based planning and RPTW neural networks to construct an intelligent environment for health care. *Expert Systems with Applications, 36*(3), 5844-5858. doi: 10.1016/j.eswa.2008.07.029

Bertelsen, P., & Nøhr, C. 2005, The work practice of medical secretaries and the implementation of electronic health records in Denmark. *Health Information Management, 34*(4), 104-111.

Bose, R. 2003, Knowledge management-enabled health care management systems: capabilities, infrastructure, and decision-support. *Expert Systems with Applications, 24*, 59-71.

Broda, T., & Clugage, K. 2006, Improving Business Operations With Real-Time Information: How to Successfully Implement a BAM Solution. *Business Integration Journal* Retrieved 22/2/2013

Chang, I. C., Hwang, H.-G., Hung, W.-F., & Li, Y.-C. 2007, Physicians' acceptance of pharmacokinetics-based clinical decision support systems. *Expert Systems with Applications, 33*(2), 296-303. doi: 10.1016/j.eswa.2006.05.001

Cheng, C., Wang, J., & Li, C. 2008, Forecasting the number of outpatient visits using a new fuzzy time series based on weighted-transitional matrix. *Expert Systems with Applications, 34*(4), 2568-2575. doi: 10.1016/j.eswa.2007.04.007

Chiasson, M. W., & Davidson, E. 2004, Pushing the contextual envelope: developing and diffusing IS theory for health information systems research. *Information and Organization, 14*(3), 155-188. doi: 10.1016/j.infoandorg.2004.02.001

Constantinides, P., & Barrett, M. 2006, Negotiating ICT development and use: The case of a telemedicine system in the healthcare region of Crete. *Information and Organization, 16*(1), 27-55. doi: 10.1016/j.infoandorg.2005.07.001

Constantinides, P., & Barrett, M. 2012, A narrative networks approach to understanding coordination practices in emergency response. *Information and Organization, 22*(4), 273-294. doi: 10.1016/j.infoandorg.2012.07.001

Corral, K., Griffin, J., & Jennex, M. 2005, 'Experts' perspective'. *Business Intelligence Journal, 10*(1), 36-40.

Del Chiappa, G. 2013, Internet versus travel agencies: the perception of different groups of Italian online buyers. *Journal of Vacation Marketing, 19*, 55-66.

Devlin, B. 1997, *Data Warehouse: From Architecture to Implementation*: Reading, MA: Addison Wesley Longman.

Dobbs, T., Stone, M., & Abbott, J. 2002, UK data warehousing and business intelligence implementation. *Qualitative Market Research: An International Journal, 5*(4), 235=238.

Duan, Y., Ong, V. K., Xu, M., & Mathews, B. 2012, Supporting decision making process with "ideal" software agents – What do business executives want? *Expert Systems with Applications, 39*(5), 5534-5547. doi: 10.1016/j.eswa.2011.11.065

Ellingsen, G., & Monteiro, E. 2003, Mechanisms for producing a working knowledge: Enacting, orchestrating and organizing. *Information and Organization, 13*(3), 203-229. doi: 10.1016/s1471-7727(03)00011-3

Escobar-Rodríguez, T., Monge-Lozano, P., Romero-Alonso, M., & Bolívar-Raya, A. 2012, Deploying information technology and continuous control monitoring systems in hospitals to prevent medication errors. *Health information management journal, 41*(1), 17-25.

Folinas, D. K. 2007, A conceptual framework for business intelligence based on activities monitoring systems. *International Journal of Intelligent Enterprise 1*(1), 65-80.

Folinas, D. K., Bochtis, D. D., & Sorensen, C. A. G. 2011, In-field logistics processes management based on business activities monitoring systems paradigm. *International Journal of Logistics Systems and Management, 8*(1), 1-18. doi: 10.1504/ijlsm.2011.037416

Gaskin, D., Briesacher, B., Limcangco, R., & Brigantti, L. 2006, Exploring racial and ethnic disparities in prescription drug spending and use among Medicare beneficiaries. *The American Journal* of Geriatric Pharmacotherapy, 4, 96-111.

Han, K. H., Choi, S.-H., Kang, J.-G., & Lee, G. 2010, *Performance-Centric Business Activity Monitoring Framework for Continuous Process Improvement* Paper presented at the The 9th WSEAS International Conference on Artificial intelligence, knowledge engineering and data bases University of Cambridge, Cambridge, UK, February 20-22, 2010.

Han, K. H., & Kang, J. G. 2007, A Process-Based Performance Measurement Framework for Continuous Process Improvement. *International Journal of Industrial Engineering-Theory, Application and Practice, 14*(3), 220-228.

Hayes, N. 2001, Boundless and bounded interactions in the knowledge work process: the role of groupware technologies. *Information and Organization, 11*, 79-101.

Jackson, S. 2011, Organizational culture and information systems adoption: A three-perspective approach. *Information and Organization, 21*(2), 57-83. doi: 10.1016/j.infoandorg.2011.03.003

Jamal, A., McKenzie, K., & Clark, M. 2009, The impact of health information technology on the quality of medical and health care: a systematic review. *Health information management journal, 38*(3), 26-37.

Janiesch, C., Matzner, M., & Müller, O. 2012, Beyond process monitoring: a proof-of-concept of event-driven business activity management. *Business Process Management Journal, 18*(4), 625-643.

Jimenez-Rubio, D., & Hernandez-Quevedo, C. 2010, Explaining the demand for pharmaceuticals in Spain: are there differences in drug consumption between foreigners and the Spanish population? [Comparative Study]. *Health Policy, 97*(2-3), 217-224. doi: 10.1016/j.healthpol.2010.05.003

Kang, B., Kim, D., & Kang, S.-H. 2012, Periodic performance prediction for real-time business process monitoring. *Industrial Management & Data Systems, 112*(1), 4-23.

Kang, D., Lee, S., Kim, K., & Lee, J. Y. 2009, An OWL-based semantic business process monitoring framework. *Expert Systems with Applications, 36*(4), 7576-7580. doi: 10.1016/j.eswa.2008.09.027

Kaplan, S., & Norton, P. 1992, The Balanced Scorecard - Measures that Drive Performance. *Harvard Business Review, 70*(1), 71-79.

Korol, T. 2013, Early warning models against bankruptcy risk for Central European and Latin American enterprises. *Economic Modelling,* 31, 22-30.

Lambrelli, D., & O'Donnell, O. 2011, The impotence of price controls: failed attempts to constrain pharmaceutical expenditures in Greece. [Research Support, Non-U.S. Gov't]. *Health Policy, 101*(2), 162-171. doi: 10.1016/j.healthpol.2010.08.023

Leggat, S. 2008, Hospital planning: the risks of basing the future on past data. *Health information management journal, 37*(3), 6-14.

Lewis, B., Harvey, K., Dartnell, J., & Sheph, J. 2004, Modelling and encoding Therapeutic Guidelines: applying ICD-10-AM and European Article Number codes. *Health Information Management, 32*(2), 51-58.

Lexchin, J., & Grootendorst, P. 2004, Effects of prescription drug user fees on drug and health services use and on health status in vulnerable populations: a systematic review of the evidence. *International Journal of Health Services, 34*(1), 101-122.

Lin, C., Lin, C. M., Lin, B., & Yang, M.-C. 2009, A decision support system for improving doctors' prescribing behavior. *Expert Systems with Applications, 36*(4), 7975-7984. doi: 10.1016/j.eswa.2008.10.066

Liu, Y. M., Yang, Y. H., & Hsieh, C. R. 2011, The determinants of the adoption of pharmaceutical innovation: evidence from Taiwan. [Research Support, Non-U.S. Gov't]. *Soc Sci Med, 72*(6), 919-927. doi: 10.1016/j.socscimed.2010.12.027

Ma, C., Chou, D., & Yen, D. 2000, Data warehousing, technology assessment and management. *Industrial Management and Data Systems, 100*(3), 125-135.

McCarthy, T. M., Davis, D. F., Golicic, S. L., & Mentzer, J. T. 2006, The evolution of sales forecasting management: A 20 year longitudinal study of forecasting practices. *Journal of Forecasting, 24*, 303-324.

Okunade, A. A., & Murthy, V. N. R. 2002, Technology as a 'major driver' of health care costs: a cointegration analysis of the Newhouse conjecture. *Journal of Health Economics, 21*, 147-159.

Robinson, K., & Shepheard, J. 2004, Predicting the influence of the electronic health record on clinical coding practice in hospitals. *Health Information Management, 32*(3&4), 102-108.

Smith, M. (2001). Companies using BI tools to look within. *Business* Intelligence. Retrieved from www.advisor.com website:

Sokolova, M. V., & Fernández-Caballero, A. 2009, Modeling and implementing an agent-based environmental health impact decision support system. *Expert Systems with Applications, 36*(2), 2603-2614. doi: 10.1016/j.eswa.2008.01.041

Sørby, I., & Nytrø, Ø. 2005, Does the electronic patient record support the discharge process? A study on physicians' use of clinical information systems during discharge of patients with coronary heart disease. *Health Information Management, 34*(4), 112-119.

Štěpnička, M., Cortez, P., Donate, J. P., & Štěpničková, L. 2013, Forecasting seasonal time series with computational intelligence: On recent methods and the potential of their combinations. *Expert Systems with Applications, 40*(6), 1981-1992. doi: 10.1016/j.eswa.2012.10.001

Syntetos, A. A., Nikolopoulos, K., & Boylan, J. E. 2010, Judging the judges through accuracy-implication metrics: The case of inventory forecasting. *International Journal of Forecasting, 26*(1), 134-143. doi: 10.1016/j.ijforecast.2009.05.016

Syntetos, A. A., Nikolopoulos, K., Boylan, J. E., Fildes, R., & Goodwin, P. 2009, The effects of integrating management judgement into intermittent demand forecasts. *International Journal of Production Economics, 118*(1), 72-81. doi: 10.1016/j.ijpe.2008.08.011

Xu, D., Wijesooriya, C., Wang, Y.-G., & Beydoun, G. 2011, Outbound logistics exception monitoring: A multi-perspective ontologies' approach with intelligent agents. *Expert Systems with Applications*. doi: 10.1016/j.eswa.2011.04.111