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## Evaluation of the efficiency of integrated ERP system and Business Intelligence tools in the application case in health care and public administration

### 1. Introduction

The research implemented over the last five years concerns analysis of the determinants of ERP systems' implementation and Business Intelligence tools in a hospital and in public administration agencies. It justifies the attempt to make a synthesis of former publications. Many aspects of the problem were presented in Volume 59 of the "Studies & Proceedings", published by the Polish Association for Knowledge Management<sup>1</sup>.

The problems which were considered in the literature<sup>2</sup> and include results of evaluation of empirical studies on the effective implementation of the new

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<sup>1</sup> L. Drelichowski, S. Bobek, W. Bojar, W. Chęsy, B. Cylski, W. Czechumski, E. Feoli, E. Fronczak, P. Ganis, C. Graul, T. Gruden, M. Gvozdenović, M. Kołodziejcki, R. Lewandowski, M. Łagodziński, G. Oszuścik, J. Siwiec, S. Sternad, K. Wawrzyniak, H. Zarzycki, *Methodological aspects and case studies of Business Intelligence applications tools in Knowledge Management*, "Studies & Proceedings" 2012, vol. 59, Polish Association for Knowledge Management, Bydgoszcz.

<sup>2</sup> L. Drelichowski, *Czynniki determinujące zastosowanie narzędzi business intelligence w sektorze MSP oraz zarządzaniu regionalnym*, "Studia Informatica" 2009, no. 24, pp. 111–122; L. Drelichowski, *Narzędzia wspomagania wdrożeń systemów zintegrowanych jako źródło przewagi konkurencyjnej adaptacji do zmian zachodzących w otoczeniu*, Komputerowe Systemy Zarządzania WN WZ UW, Warszawa 2009; L. Drelichowski, M. Stawicka, B. Cylski, *Budowa Międzyregionalnych Hurtowni Danych i rozwiązań automatycznych analiz cenników i kosztów*

standards of the strategy of formation of integrated systems. Article<sup>3</sup> describes examples of applications of Business Intelligence solutions in a medium-size hospital, where the solutions were intended to improve the efficiency of financial management, which is a weak point of a great number of public health care facilities. A comprehensive analysis of the efficiency of various areas of medical services provided by the hospital was presented in a number of reports generated by a data warehouse developed within the SIMPLE ERP system and conveyed using OLAP tools. The high rank of ERP systems as a basis for applications of a data warehouse and BI tools has been emphasised by numerous researchers<sup>4</sup>. The development of a data warehouse and reporting by means of OLAP tools improved the process of efficient management through the hospital economic director's collaboration in the design of the BI solutions.

Article<sup>5</sup> describes an example of applications of a data warehouse and BI tools to enhance medical diagnosis processes and improve therapeutic decision-making in the Oncology Centre in Bydgoszcz.

Chapter 3 shows examples of negative effects of the implementation of BI solutions in public administration, the causes of which were identified thanks to positive experiences (Chapter 4) resulting from long-term use of BI solutions at the POZKAL printing house in Inowrocław.

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*działalności firm usług komunalnych dla potrzeb władz samorządowych*, "Studia i Materiały" Polskiego Stowarzyszenie Zarządzania Wiedzą, no. 25, Bydgoszcz 2010, pp. 42–53.

<sup>3</sup> L. Drelichowski, S. Bobek, W. Bojar, W. Chęsy, B. Cilski, W. Czechumski, E. Feoli, E. Fronczak, P. Ganis, C. Graul, T. Gruđen, M. Gvozdzeniów, M. Kołodziejski, R. Lewandowski, M. Łagodziński, G. Oszućcik, J. Siwiec, S. Sternad, K. Wawrzyniak, H. Zarzycki, op.cit.

<sup>4</sup> J. Choe, *Inter-organizational relationship and the flow of information through value chains*, "Information & Management" 2008, vol. 45, pp. 444–450; B. Czarnacka-Chrobot, *Typowe czynniki niepowodzenia w realizacji informatycznych przedsięwzięć projektowych – spojrzenie Standish Group*, in: *Dylematy zarządzania projektem informatycznym*, eds M. Miłosz, J.K. Grabara, Polskie Towarzystwo Informatyczne, Katowice 2006; J.J.P.A. Hsieh, W. Wang, *Explaining Employees' Extended Use of Complex Information Systems*, "European Journal of Information Systems" 2007, vol. 16, no. 3, pp. 216–227; G. Klimek, J. Unold, *Wiki jako nowoczesne narzędzie zarządzania wiedzą. Wiedza i komunikacja w innowacyjnych organizacjach*, Wydawnictwo UE, Katowice 2011; K.Y. Kwahk, J.N. Lee, *The Role of Readiness for Change in ERP Implementation: Theoretical Bases and Empirical Validation*, "Information & Management" 2008, vol. 45, no. 7, pp. 474–481; D.H. Lee, S.M. Lee, D.L. Olson, S.H. Chung, *The Effect of Organizational Support on ERP Implementation*, "Industrial Management & Data Systems" 2010, vol. 110, no. 1–2, pp. 269–283; Y.Y. Shih, S.S. Huang, *The Actual Usage of ERP Systems: An Extended Technology Acceptance Perspective*, "Journal of Research and Practice in Information Technology" 2009, vol. 41, no. 3, pp. 263–276.

<sup>5</sup> R. Lewandowski, K. Wawrzyniak, M. Łagodziński, G. Fronczak, W. Czechumski, *The application of business intelligence solutions in a health care organization*, "Studies & Proceedings" PSZW, vol. 58, Bydgoszcz.

## **2. Method of an integrated ERP implementation of a field-specific data warehouse and OLAP system in medium size hospitals**

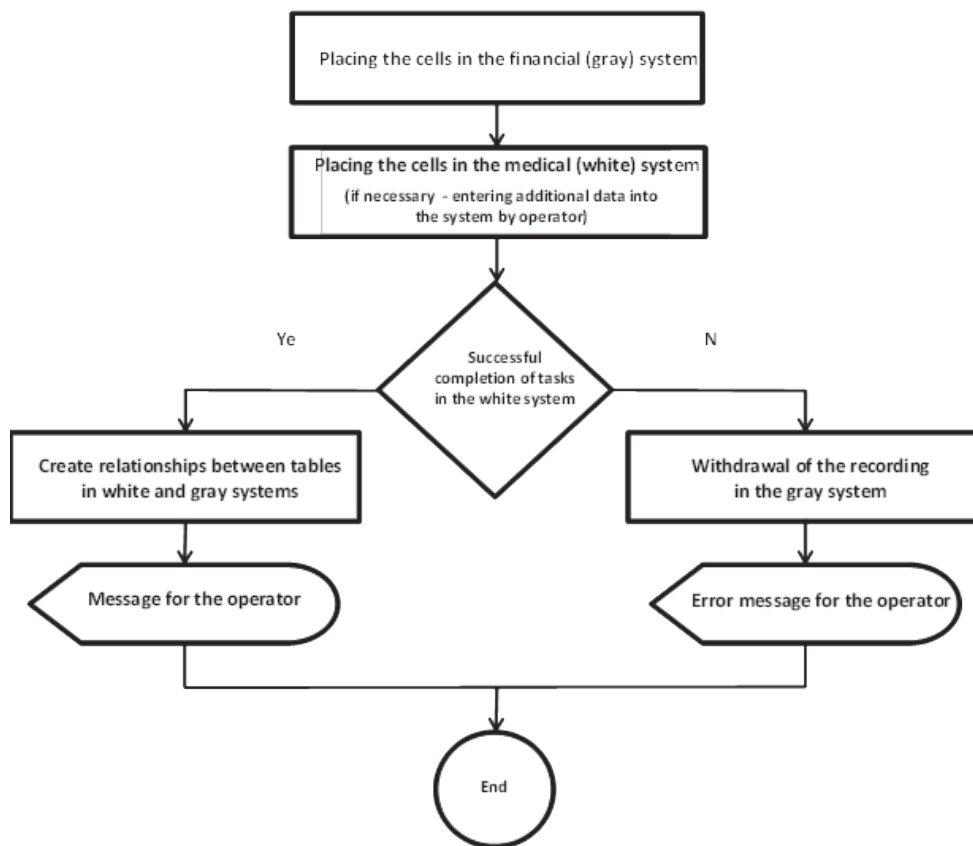
In the present-day realities of health care institutions, the financial management of medium-size hospitals is one of the most important elements determining their economic standing. In order to ensure effective financial management of this kind of institution, a comprehensive information system, encompassing practically all areas of activity, is indispensable. SOFTEAM has introduced such information systems in a dozen or so public health care facilities, ranging from outpatient clinics to hospitals of different size. The implementations include an integrated ERP Information System to serve finance and accounting, administration, human resources management, assets and inventory management, as well as information and financial reporting systems (the grey part of the IS). The health care projects are particularly complex, involving a great variety of issues in numerous areas and a great number and rotation of assets.

Let us look at the example of an organisational structure to see some different possibilities for data integration.

### **2.1. In the grey and white parts the organisational structures are identical**

It is only necessary to introduce a one-to-one relation for the corresponding organisational unit tables in both parts of the system and to develop procedures to ensure coherence (when a unit is added in one part it also appears in the other).

In the grey part, the organisational structure is less detailed than in the white part, however the manner of aggregation of units from the grey system to the level of detail of the white system can be established in a straightforward manner. For example, the unit designated as the 'Diagnostic Imaging Unit' corresponds to three units in the white part: 'X-ray Lab', 'Ultrasound Lab', and 'Bronchoscopy Room', which requires creation of an intermediate table to allow aggregation of the data and completion of a correlated table when new units are added.



**Figure 1. Example procedure for retaining integrity of integrated systems**

Source: L. Drelichowski, S. Bobek, W. Bojar, W. Chęsy, B. Cilski, W. Czechumski, E. Feoli, E. Fronczak, P. Ganis, C. Graul, T. Gruden, M. Gvozdzenović, M. Kołodziejcki, R. Lewandowski, M. Łagodziński, G. Oszućik, J. Siwec, S. Sternad, K. Wawrzyniak, H. Zarzycki, *Methodological aspects and case studies of Business Intelligence applications tools in Knowledge Management*, "Studies & Proceedings" 2012, vol. 59, Polish Association for Knowledge Management, Bydgoszcz.

**Figure 2. Example of a table designed to correlate organisational units**

Field identifier	Description
id	table own id (basic key)
id_grey	grey part table id (unique key)
id_white	white part table id (id_grey + id_white (unique key))

Source: own research.

The organisational structure in the grey part is more detailed than in the white part, however the records in the white part can be separated to reach the level of detail of the grey system, using other kinds of information:

- This requires creation of an intermediate database in which a table is used to store specific quantitative (numerical) and value data from the white part for each unit of the grey part, and introduction of disaggregation procedures based on detailed data from the white system.

**Figure 3. Example of a table designed to store disaggregated data of organisational units**

Field identifier	Description
id	table own id (basic key)
id_grey	grey part table id (unique key)
quantities_grey	Disaggregated quantitative data from the white part
values_grey	Disaggregated value data from the white part

Source: L. Drelichowski, S. Bobek, W. Bojar, W. Chęsy, B. Cilski, W. Czechumski, E. Feoli, E. Fronczak, P. Ganis, C. Graul, T. Gruden, M. Gvozdzenović, M. Kołodziejcki, R. Lewandowski, M. Łagodziński, G. Oszućcik, J. Siwiec, S. Sternad, K. Wawrzyniak, H. Zarzycki, *Methodological aspects and case studies of Business Intelligence applications tools in Knowledge Management*, "Studies & Proceedings" 2012, vol. 59, Polish Association for Knowledge Management, Bydgoszcz.

The organisational structures in the grey and white parts are completely different and there is no information allowing automatic aggregation or disaggregation of the data:

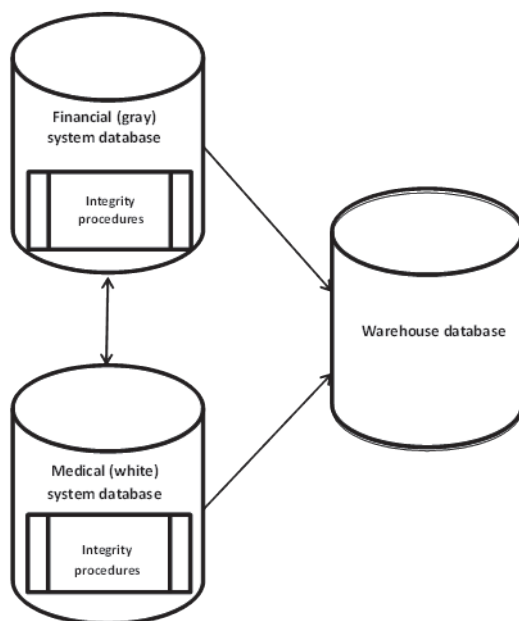
- This requires creation of an intermediate database with a table to store specific quantitative and value data from the white part for each unit of the grey part and provision of a user interface to allow relevant classification,
- If possible, the best solution is to re-implement the systems to achieve one of the cases described in 1, 2 or 3 above.

The four basic case described above are only largely simplified examples, and as such do not cover all possible combinations and correlations that may occur between the two database systems. In real-life situations, mixed approaches are often necessary, as different data dictionaries may have different levels of integrity. Sometimes, the data processed in an operational data store is reallocated to the source bases (as supplementary tables and fields), which may improve the processes of supply in the data warehouse over subsequent cycles. An additional hindrance may come from technical constraints, which may not allow creation of correlations between tables and application of procedures to ensure compatibility of the dictionary records despite their logical incompatibility.

## 2.2. Another significant factor when integrating database systems is to ensure coherence of units of measure, failing which serious calculation errors can occur

The solutions indicated above consider only some of the key elements in designing and planning integration of ERP solutions used in the grey system with the solutions used in the white system. It should be noted that without an efficient resolution to the problem, it is impossible to provide adequate reporting ensuring payback of the costs incurred by hospitals under contracts with the National Health Fund (NFZ).

The dominant part of the system during integration is the grey system (the ERP system), which stores most of the financial data, whereas the white part (the medical system) stores information which serves to correctly allocate the financial data in reports.



**Figure 4. Simplified diagram of a data warehouse supply in case of compliance dictionaries in the gray and white systems**

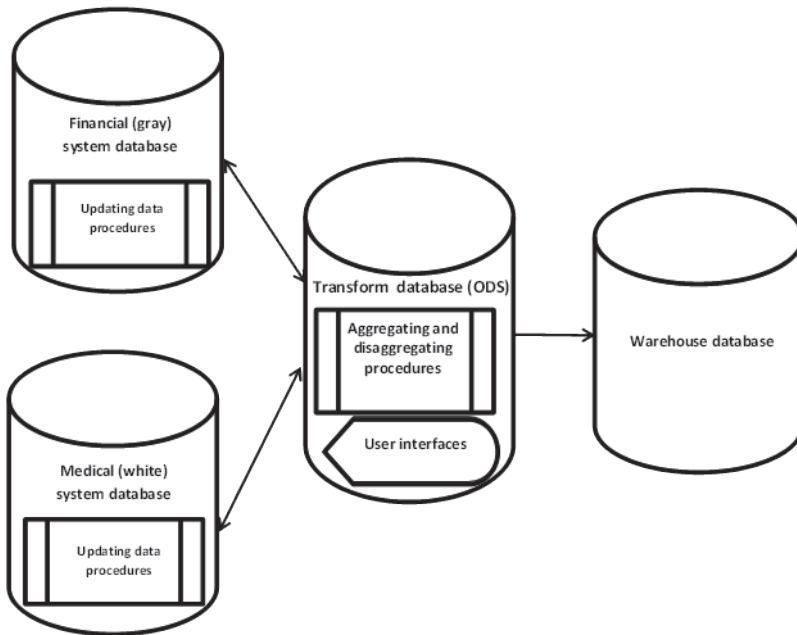
Source: L. Drelichowski, S. Bobek, W. Bojar, W. Chęsy, B. Cilski, W. Czechumski, E. Feoli, E. Fronczak, P. Ganis, C. Graul, T. Gruden, M. Gvozdenović, M. Kołodziejcki, R. Lewandowski, M. Łagodziński, G. Oszućcik, J. Siwec, S. Sternad, K. Wawrzyniak, H. Zarzycki, *Methodological aspects and case studies of Business Intelligence applications tools in Knowledge Management*, "Studies & Proceedings" 2012, vol. 59, Polish Association for Knowledge Management, Bydgoszcz.

In the process of implementation of an information and financial reporting system a very significant role is played by the user’s financial and accounting service, which is not only engaged in development of the fundamental concept, but also has to deal with relevant financial records (mainly related to costs) and their corresponding medical records.

In a medical institution, in order to account the costs correctly and to obtain accurate reports, the right source data is necessary. These include:

- Payroll data (compensation divided by cost centres),
- Inventory management system data (use of materials and medicines, divided by cost centres),
- Cost-driving purchases (purchases divided by cost centres),
- Cost distribution lists (method of cost allocation in auxiliary units),
- Inpatient data (length of stay, applied procedures, etc.).

Records of the first three elements are kept in the ERP system, whereas the last two are made in the medical system (the white part).



**Figure 5. Simplified diagram of a data warehouse supply in case of no compliance dictionaries in the gray and white systems**

Source: L. Drelichowski, S. Bobek, W. Bojar, W. Chęsy, B. Cieliski, W. Czechumski, E. Feoli, E. Fronczak, P. Ganis, C. Graul, T. Gruden, M. Gvozdenović, M. Kołodziejcki, R. Lewandowski, M. Łagodziński, G. Oszuścik, J. Siwiec, S. Sternad, K. Wawrzyniak, H. Zarzycki, *Methodological aspects and case studies of Business Intelligence applications tools in Knowledge Management*, “Studies & Proceedings” 2012, vol. 59, Polish Association for Knowledge Management, Bydgoszcz.

The ERP system is also used to prepare cost distribution lists in auxiliary units. To this end it applies automatic reclassification and import of data from the medical system. However, it is seldom possible to predict and formulate rules and conversion algorithms directly. In such cases, the cost distribution is attempted using elements of a BI system based on a data warehouse, which performs a multidimensional analysis and prepares the data for the user, who can run a simulation, make necessary corrections and finally approve the manner of cost distribution. An efficient information system supports such operations in one cycle, divided into four phases:

- Initial preparation and calculation of data by the ERP system and its subsequent transfer to the BI system data warehouse,
- Automatic launch of a relevant OLAP analysis and provision of a user interface to enable review and correction of results,
- Edition of the results by the user (simulations, correction, acceptance etc.),
- Return of user-accepted data to the ERP system in the form of a book entry.

For a more detailed discussion of the solutions offered by a BI system and examples of reports used in the hospital are refer to<sup>6</sup>.

### 3. Business Intelligence tools implementation in public administration agencies

BI systems play a particularly significant role in the financial and settlement support process of the organizational units' budgets in the area of funds earmarked for monitoring tasks. They allow for provision of a complex system reporting the current condition at any subjective or generic cross section.

These kinds of information systems are usually supplied with data from existing accounting systems that may have been modified in recent years.

If we accept the assumption that the creation of this type of system solution requires ORACLE data warehousing technology, or an ORACLE data mining application with the assistance of a professional implementation company, we can expect that the system implementation will be successful. But the author's experience shows that two examples of successfully executed and implemented system solutions have been interrupted after one year of exploitation.

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<sup>6</sup> L. Drelichowski, S. Bobek, W. Bojar, W. Chęsy, B. Cilski, W. Czechumski, E. Feoli, E. Fronczak, P. Ganis, C. Graul, T. Gruden, M. Gvozdzenović, M. Kołodziejski, R. Lewandowski, M. Łagodziński, G. Oszuścik, J. Siwiec, S. Sternad, K. Wawrzyniak, H. Zarzycki, op.cit.



Since success has many parents and defeat is an orphan, it was difficult to discover the reasons for these resignations from correctly implemented and developed system solutions.

In one case, the explanation behind the discontinuation of a good BI system's use seems to be completely explained by the theory in Chapter 4 of this paper (Figures 6 and 7).

Most BI systems are created based on information stored in transactional systems without direct feedback from the system's users. In the stream of hundreds of thousands of data records that are moved every week or month, code conversion errors in the source data or data warehouse information flow are unavoidable. In this situation, the registration information which is stored in the data warehouse and used mainly for BI system calculations becomes incompatible with the actual values. This creates a lack of confidence in the reports received by the system's users and leads to the company or body's resignation from further BI systems use.

The implementation of organised data processing solutions as presented in Figure 7 seems to be an apparently simple procedure. It is easier to establish, together with the new ERP standard, a system which is related to data warehouse implementation and its supply from the registration reports storage that is essential to the information services of operational management support.

Implementation of these kinds of solutions may cause concern from users who are located at different levels of the management hierarchy. To avoid this problem, decisions by the highest management levels are required (which occurred at the POZKAL company).

A lack of such decisions means that more preferable implementations become those which do not provide feedback from users of the operating management functions.

#### **4. Data processing organization and a data warehouse with OLAP tools as the success factors in the application of a BI solution at the POZKAL company**

The discussed ERP system solutions for the company from the printing sector did not constitute any particularly innovative technologies, although they may provide a unique standard by the application of specific data processing organization. The use of a controlling application based on the ABC approach can

be an example of a more effective approach to the management of fixed assets. Three-year long experiences gained by effective operation of a data warehouse and OLAP tools for operational, tactical and strategic decision support could even represent some added value.

Figure 6 shows the most frequent data processing solutions used by organizations, which range from the formation of source documents, through storing them in a transactional database, transferring them to a data warehouse and generating reports with OLAP tools, data mining and to generation of graphical outputs. Figure 7 presents the solutions which implemented at the POZKAL company. There are some significant differences between their processing and the processing of the organization presented in the figure.

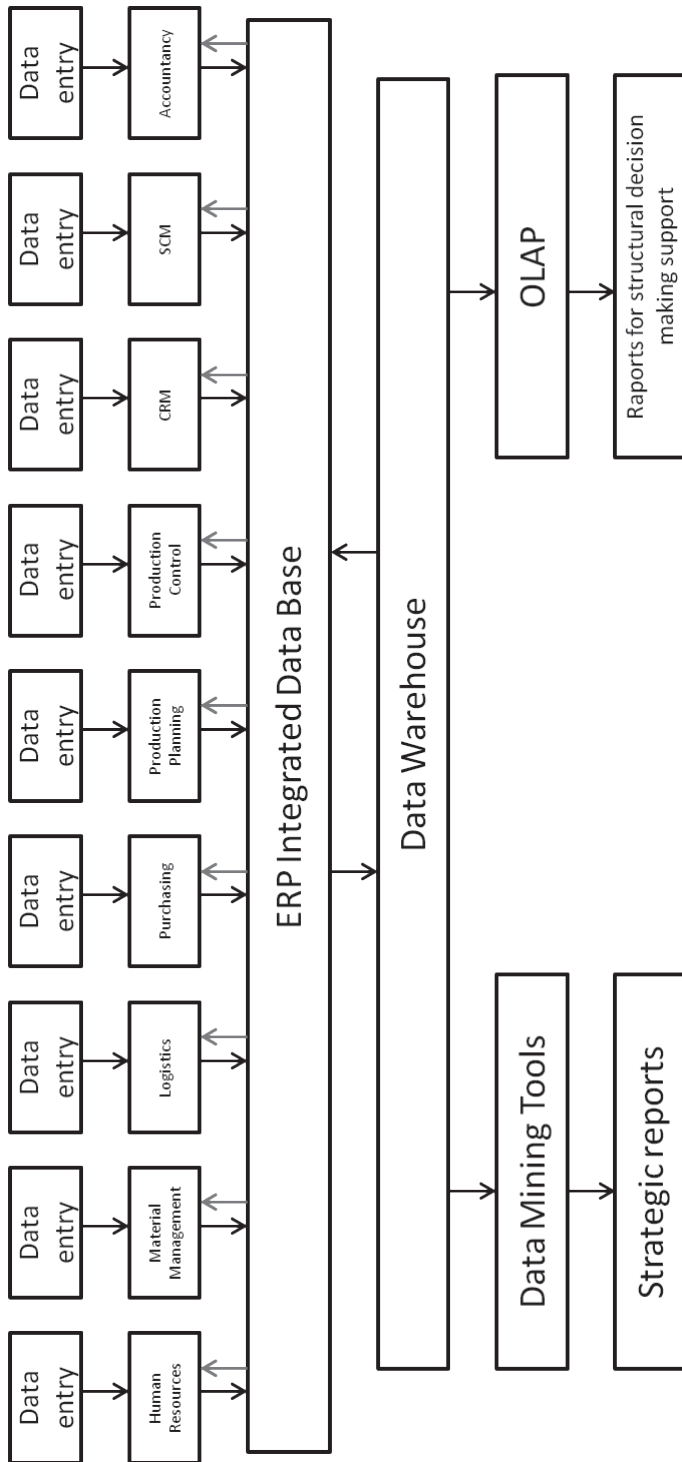
The differences are connected with an extremely important process of updating the data warehouse solutions, which is done at the end of the transaction processing day and provides feedback and records verification in the area of operational information. The registration data which is generated at the beginning of the following day can then provide a basis for later information processing, when the data is acquired from the data warehouse. The processed information can also be a basis for creating source documents and accounting records.

The solution that have been implemented in the POZKAL company seems to be self-evident but is probably rarely applied in practice. This follows from the fact that the data warehouse application for the operational information formation may raise some doubts, both in the management team and in the rest of the staff<sup>7</sup>.

These concerns may be justified because the decision of the complex data warehouse update process implementation as a single operational information supply in the organization (Figure 7) was risky and courageous.

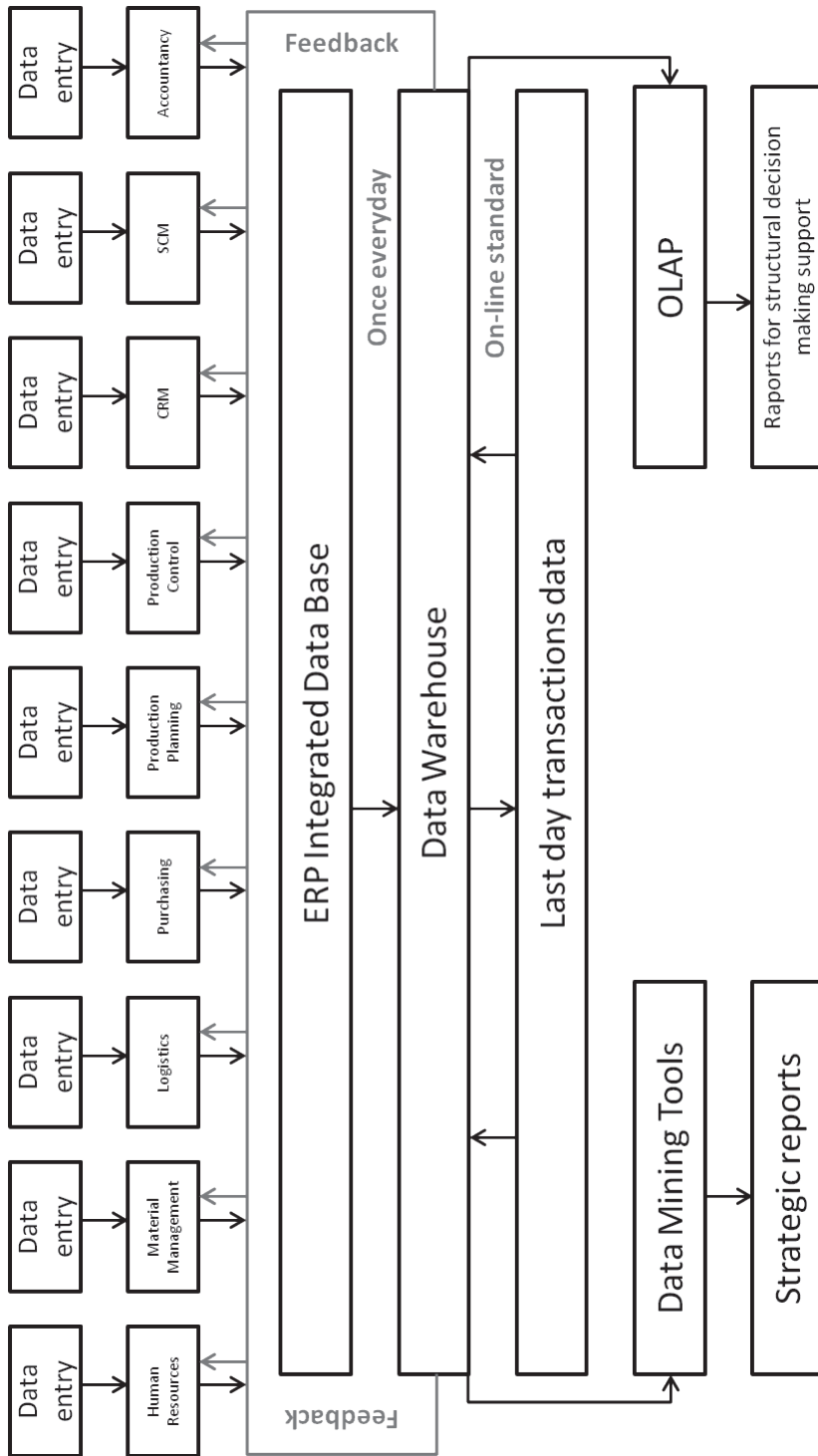
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<sup>7</sup> Ibidem; E.J. Umble, R.R. Haft, M.M. Umble, *Enterprise Resource Planning: Implementation Procedures and CSF*, "European Journal of Operational Research" 2002, vol. 146, no. 2, pp. 241–257; F.M.E. Uzoka, R.O. Abiola, R. Nyangeresi, *Influence of Product and Organizational Constructs on ERP Acquisition Using an Extended Technology Acceptance Model*, "International Journal of Enterprise Information Systems" 2008, vol. 4, no. 2, pp. 67–83.



**Figure 6. Typical integrated data processing system**

Source: L. Drelchowski, S. Bobek, W. Bojar, W. Cheży, B. Cilski, W. Czechumski, E. Feoli, E. Fronczak, P. Ganis, C. Graul, T. Gruden, M. Gvozdenović, M. Kołodziejcki, R. Lewandowski, M. Łagodziński, G. Oszućik, J. Siwiec, S. Sternad, K. Wawrzyniak, H. Zarzycki, *Methodological aspects and case studies of Business Intelligence applications tools in Knowledge Management*, "Studies & Proceedings" 2012, vol. 59, Polish Association for Knowledge Management, Bydgoszcz.



**Figure 7. Integrated data processing system with feedback solution**

Source: L. Drelichowski, S. Bobek, W. Bojar, W. Chęsy, B. Cilski, W. Czechumski, E. Feoli, E. Fronczak, P. Ganis, C. Graul, T. Gruden, M. Gvozdenović, M. Kolodziejcki, R. Lewandowski, M. Łagodziński, G. Oszuścik, J. Siwiec, S. Sternad, K. Wawrzyniak, H. Zarzycki, *Methodological aspects and case studies of Business Intelligence applications tools in Knowledge Management*, "Studies & Proceedings" 2012, vol. 59, Polish Association for Knowledge Management, Bydgoszcz.

The application of precise data warehouse update algorithms that have been tested before implementation and its merging with the last day transactional data analysis could raise the doubts about the precision of these operations. The results of the three-year application of this solution at the POZKAL company proved to be fully effective from the perspective of long-term implementation. The benefits of these solutions are obvious, because the transaction data records are valid only if they are regularly verified by all data processing functions within the organization.

The conclusions which have been formulated in this chapter can provide a basis for finding an explanation of the poor implementation or even resignation from correctly designed and implemented BI systems within organizations.

## 5. Conclusions

The synthetic summary of results of research described in this paper and carried out in a number of other organizations was focused on the implementation of early identification of possible factors that can be crucial to efficient implementation of ERP and Business Intelligence tools<sup>8</sup>.

1. However, it is seldom possible to predict and formulate rules and conversion algorithms presented in Chapter 2 directly. In such cases the cost distribution is attempted using elements of a BI system based on a data warehouse, which performs a multidimensional financial analysis and prepares the data for users who can run a simulation, make necessary corrections and finally approve the manner of cost distribution in the given hospital.
2. Implementation of this kind of solutions may give rise to some concerns of users who are located at different levels of a managerial hierarchy and have to pay attention to precise data warehouse implementation. This was the reason why two examples of successfully executed and implemented system

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<sup>8</sup> J. Kisielnicki, *MIS Systemy Informatyczne Zarządzania*, Placet, Warszawa 2008; P. Kobis, *Poziom informatyzacji dużych przedsiębiorstw w Polsce w aspekcie wykorzystania grupowych technik wspomaganie decyzji oraz technik multimedialnych. Wiedza i komunikacja w innowacyjnych organizacjach*, Wydawnictwo UE, Katowice 2011; P. Lech, *80/20 Role in ERP System Implementation – A Case Study on Maximizing ROI*, Proceedings of then 11-th European Conference on Information Technology Evaluation, Genoa 2004, pp. 342–352; E. Youngberg, D. Olsen, K. Hauser, *Determinants of Professionally Autonomous End User Acceptance in an Enterprise Resource Planning System Environment*, "International Journal of Information Management" 2009, vol. 29, pp. 138–144.

solutions were given up after only one year of operation. To avoid such issues, the selection of suitable representatives of the top management is required (as it occurred at the POZKAL company). With a lack of determination more preferred implementations turn out to be these which do not provide feedback from users of the operating management

3. Synthetic analysis of operating experience of the ERP system, data warehouse and OLAP tools at POZKAL in Inowrocław have allowed precise definition of two models of system exploitation (Figure 6), with the introduction of a feedback model, ensuring the correctness of the information in the data warehouse, and a model without such feedback (Figure 6). The implementation of solutions presented in Model II (Figure 7) allows us to explain the reasons for the abandonment of certain interesting systems which contained BI tools, after just a few months of exploitation, because it was not guaranteed that registration records were compatible with the data stored in the data warehouse.

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## **Ocena efektywności zastosowań systemów zintegrowanych ERP oraz narzędzi Business Intelligence w ochronie zdrowia i administracji publicznej**

### **Streszczenie**

Ocenę efektywności zastosowań zintegrowanych systemów klasy ERP oraz narzędzi Business Intelligence przeprowadzono w niniejszej pracy poprzez analizę przykładów ich wykorzystania w jednym z nowocześnie zarządzanych szpitali oraz doświadczeń z eksploatacji systemów BI w organach administracji publicznej. Analiza sukcesów oraz zaskakujących porażek pozwoliła sprecyzować kluczowe czynniki powodzenia lub porażki w zakresie efektywności zastosowań narzędzi BI w zarządzaniu. Stwierdzone zasady zapewnienia bezwarunkowej zgodności zawartości hurtowni danych z bazami danych transakcyjnych stanowią, zdaniem autorów, warunek konieczny długookresowego sukcesu zastosowania BI w procesach podejmowania decyzji. Rozwiązania takie zapewnić może proponowany w pracy system organizacji przetwarzania danych skutecznie zweryfikowany w wieloletniej eksploatacji w przedsiębiorstwie poligraficznym POZKAL w Inowrocławiu. Rozwiązanie takie wymusza zgodność baz danych transakcyjnych z zawartością hurtowni danych, często niedocenianą przez autorów publikacji z tej dziedziny.

**Słowa kluczowe:** systemy zintegrowane klasy ERP, hurtownie danych, bazy danych transakcyjnych, narzędzia Business Intelligence (BI)