MASTER

Process improvement in mental healthcare

a data-based method for care delivery process analysis in GGzE centre child and adolescent psychiatry

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Award date:
2010

Eindhoven, June 2010

Process improvement in mental healthcare: A data-based method for care delivery process analysis in GGzE Centre child and adolescent psychiatry

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in partial fulfilment of the requirements for the degree of

Master of Science
in Operations Management and Logistics

TU/e, University of Technology Eindhoven

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Master:	Operations Management and Logistics
Specialization:	Information Systems
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TUE. Department Technology Management.
Series Master Theses Operations Management and Logistics

Subject headings: mental healthcare processes, client flows, process mining, visual analytics

Summary

Changes in governmental policy, undiminished growing demand, and increasing waiting times forces Dutch mental healthcare institutes to improve their processes. At a national level the first actions have been undertaken to manage care processes. One of the major implementations is the Diagnosis Treatment Combination (In Dutch: Diagnose Behandel Combinatie – DBC) systematic. The key element of the DBC-system is that the total treatment trajectory of a client will be reimbursed, instead of the separate treatments. Treatment trajectories in the DBC systematic are composed of two parts: the classification of the demand of care in combination with the type of care profile. The DBC systematic offers new possibilities for analyzing and improving care delivery processes. This opportunity has also been recognized by GGzE, Mental healthcare Institute of Eindhoven, which offers ambulant and clinical care to people with severe psychosocial and psychiatric disorders in and around Eindhoven. New initiatives, e.g. breakthrough projects, in order to analyze and control care delivery processes of GGzE, have made their entrance at GGzE Centre child and adolescent psychiatry. GGzE Centre child and adolescent psychiatry is part of the division child and adult psychiatry, and offers help to children and adolescents (0 till 23 years old) and their parents or other raisers. In particular, managers and professionals of GGzE Centre child and adolescent psychiatry are of the opinion that more measures, especially about specific processes and process phases, are desired for managing their processes. In order to deal with this problem the following research question has been formulated:

"Which method can be used to analyze data about care delivery processes in GGzE Centre child and adolescent psychiatry at a level that client flows can be identified and design solutions for logistical improvement can be developed?"

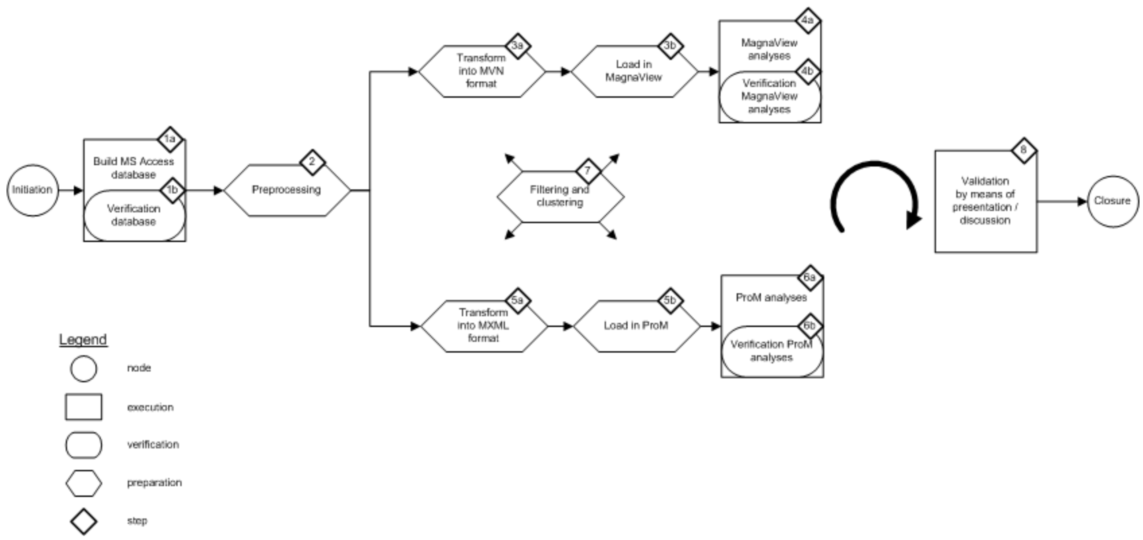
In order to answer the research question recent developments with respect to describing mental healthcare processes in general, and care delivery processes at GGzE Centre child and adolescent psychiatry in specific have been identified. In general, a client with a demand for care applies at a care institute. Although it is not yet known what this demand implies, this is where the care delivery process starts. Typically, mental healthcare processes are divided in two regularly repeating and overlapping phases, which are the specification and delivery phase. Joosten et al. (2008) argue that both care programmes (CPs) and integrated care pathways (ICPs) are needed to improve processes and quality in the mental health service specification phase and delivery phase. Furthermore, Joosten et al. (2009) that this approach could be and appropriate instrument when aiming at redesigning operation aspects of the care delivery process. In specific, GGzE Centre child and adolescent psychiatry is divided by means of routes, which arranges clients according to age of the client and the nature of his/her psychological problems. Of special interest is route 1 for which is expected that this part of the process causes most problems with regard to waiting times and organizational issues. According to Linskens (2009) route 1 includes five main processes which are application, screening, intake, assessment, and Program Coordination Point (PCP).

Second, existing methods in order to manage care delivery improvement projects have been identified. The first method of interest is developed in the Business Process Management (BPM) research domain. During a previous graduation project at Eindhoven University of Technology Riemers (2009) developed a data-based method for process analysis in healthcare using process mining and visual analytic tools. This method has been validated by Torres Ramos (2009). The main idea of the method is that the combination of process mining and visual analytics could be a good option for getting relevant healthcare process information. These approaches appear to be good complements because process mining is a process driven approach which looks at the inside of the processes while visual analytics can help users to obtain cleared process insights. The tools used in the method for process mining and visual analytics are the ProM tool and the MagnaView tool

respectively. In particular, the method focuses on the control and diagnosis phases of the BPM life cycle, in which revealing weaknesses and monitoring of processes are the main issues.

The second method of interest is developed in the Health Operations Management (OM) research domain. Vissers (2006) developed an operations management approach for process improvement. In particular the approach provides project management tools to guide the execution of patient flow projects. The approach consists of five steps which are: (1) identification of iso-process patient groups, for which a specific organization of services is developed; (2) description of these processes in a way that allows analysis of the service and resource use impacts of processes; (3) definition of a production control per patient group, taking into account the characteristics of the process considered; (4) setting objectives for the performance of the process to enable its monitoring; and (5) taking the responsibility for process management in order to make improvements process sustainability. In order to apply the method three main principles should be understand, which are: the distinction between logistics of units, chains, and networks; the framework for production control; and homogeneous process patient grouping. In addition this thesis describes a more general emerging approach in order to improve processes developed in the health OM domain. This is focused factory, which is in particular relevant since it is a widely tested concept in industry which emerges as a model for designing integrated care pathways (Joosten et al., 2008) and homogenous patient groups (Bertrand and de Vries, 2005).

For analyzing GGZ-DBC data about care delivery processes in GGzE Centre child and adolescent psychiatry a data-based method has been developed. The method is to a large extent based on the method of Riemers (2009), but differs in two important aspects: (1) for this method mental healthcare process data instead of hospital process data have been used; (2) where Riemers (2009) typically approaches a preliminary analysis and executes one iteration, the model designed for this master thesis project attempts to prescribe the required steps by means of a system approach, which is characterized by verification (i.e., checking the logic of the model) and validation (i.e., comparing the model results to reality) steps and allows iteration. Typically, the method is designed in order to perform a case study which starts with initiation and ends with closure, like with projects in general.



In summary the data-based method for mental healthcare analysis consists of the following steps: build database, preprocessing, visual analytics and process mining (both including transformation, loading, analyses, and verification), filtering and clustering, and validation. Particular attention should be paid on step 7 ‘filtering and clustering’. Due to complexity and inconveniently arrangement of healthcare processes, filtering and clustering techniques are needed in order to state conclusions about the processes and approach them more convenient. Ultimately, filtering and clustering techniques can be used in order to distinguish client groups fulfilling the iso-process patient group criteria (homogenous in terms of process and market performance).

The data-based method for mental healthcare process analysis has been applied by means of a case study at GGzE Centre child and adolescent psychiatry. The application is based on DBC-GGZ data recorded at GGzE Centre child and adolescent psychiatry. The dataset contains information concerning clients, care trajectories, DBC trajectories, diagnoses, activities, day spending activities, and days of stay. Moreover, there are additional data specifications coupled to the designed database, originating from the GGZ code lists.

The results of the case study have been divided over four categories, which are: MagnaView analyses, ProM analyses, identification of client groups, and validation of case results. The MagnaView analyses presented in the method are divided over the categories process characteristics, bottlenecks, and process patterns. Process characteristics related views are for instance: arriving pattern of clients, throughput times of clients, number of care trajectories per primary diagnosis, and activities and their originators. Bottleneck related views are: waiting times per activity, and waiting times per employee. Process patterns related views are: number of activities per care trajectory, and relative duration of care trajectories. Based on other case studies applying ProM and the capabilities with regard to complexity of the mental healthcare processes a selection of mining plug-ins and analysis plug-ins has been made in order to discover the processes.

For identification of client groups a combination of both visual analytics and process mining has been used. Based on visually analysis of the 'relative duration of care trajectories'-view, a diagram containing four distinct client groups classified on throughput time and total processing times (i.e. number of activities) characteristics has been designed. The four hypothesized client groups are: rapid discharge, long-term no treatment, diagnostic complex severe psychosocial and psychiatric disorders, and general severe psychological and psychiatric disorders. In order to verify if these groups indeed can be distinguished first a number of process indicators are selected in line with the filtering approach of the method. In particular the following filters are used: care trajectories containing more/less than 5 activities, longer/shorter waiting time (in days) between two successive activities, primary diagnosis, and client age. Based on the classification and analysis of client groups it has been concluded that indeed the client groups 'rapid discharge' and 'long-term no treatment' can be distinguished. . Furthermore another interesting group can be distinguished which is the group of client processes characterized by care trajectories where the time between two successive activities is always smaller than 30 days. In particular, this group amounts only 9% of the total care trajectories, but accounts 38% of the total performed activities in the data set. By means of comparing the activity compounding and originator constellation within the client groups processes, it is found that the group with small waiting times between activities are characterized by a relative high number of 'verblijf' and 'dagbesteding' activities, whereas client groups with at least one high waiting time between activities are characterized by a relative high number of 'diagnostiek', 'behandeling', and 'algemene indirecte tijd' activities. However the 'rapid discharge' group amounts relative few activities, it has been concluded that for this group relative a lot time is spend at 'diagnostiek' and 'algemene indirecte tijd' activities.

In order to validate the case results a number of presentations including discussions with several stakeholders and involved parties have been organized. In particular the MagnaView visualizations and the identification of client groups have been presented. The most important target group of these presentations was managers and professionals of GGzE. In addition the method has been evaluated. In particular there was concluded that the main advantages of a data visualization approach are: (i) a better understanding about the process; and (ii) a better understanding about bottlenecks within the process. Furthermore, the results have a positive effect on managing processes at GGzE Centre in child and adolescent psychiatry, because: (i) managers and profession gained insight about what really happened in their processes by means of analyses of data they registered themselves; and (ii) these insights support the desire for structural process improvement and better registration of what really occurred during care delivery processes. For GGzE Centre research and development in particular, the data-based method is of relevance, because: (i) it enables researchers to logically aggregate process data and obtain purposeful process analyses, and (ii) based on these analyses, care delivery processes could be better controlled, which serves as starting point for future process improvement.

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1 Introduction

Within this first chapter the introduction towards "Process improvement in mental healthcare: A data-based method for care delivery process analysis in GGzE Centre child and adolescent psychiatry" has been given. First the problem definition and the there from derived research question is depicted in section 1.1. The scope and the focus of the master thesis project are stated in sections 1.2 and 1.3, respectively. Then section 1.4 explains the research approach. And finally, the outline of the report is described in section 1.5.

1.1 Problem definition

Mental healthcare institutions in the Netherlands face major changes pushed by governmental policy[1]. In order to encourage competition in the market, changes with regard to financing, reallocation and privatizing the GGZ are introduced anno 2008. Another force GGZ has to deal with is the difficulty GGZ has to meet demands: research data showed that the demand of the GGZ grows undiminished. All types of care in the first-line and second-line Dutch mental healthcare show an increase from the 90s onwards; the strongest increase manifests in ambulant care, the smallest increase occurs in clinical care. Especially second-line GGZ has difficulties to handle increasing demand: the size of waiting lists and waiting times increases steady and in every phase clients wait longer than is required by the standard ('Treeknorm').

At national level the first actions have been undertaken to manage care processes. One of the major implementations is the Diagnosis Treatment Combination (In Dutch: Diagnose Behandel Combinatie – DBC) systematic. This is esteemed as an important link in the new health insurance system. The key element of the DBC-system is that the total treatment trajectory of a client will be reimbursed, instead of the separate treatments. This way of financing is termed as product financing, where the 'product' is the total treatment trajectory belonging to a demand for care. In order to enable product financing the products, or treatment trajectories, should be defined. This definitions in the DBC systematic are composed of two parts: the classification of the demand of care (in terms of diagnosis, the occasion of demand of care –regular or crisis– and the sort of demand –admission or not–) in combination with the type of care profile (the activities which are done in order to meet the demand of care and the time spend on the activities).

GGzE, Mental healthcare Institute of Eindhoven, offers ambulant and clinical care to people with severe psychosocial and psychiatric disorders in and around Eindhoven. Each year GGzE offers treatments towards about 18,000 clients. GGzE's operations are divided over three divisions which are: child and adult psychiatry, adult and elderly psychiatry, and forensic and intensive psychiatry. Each division is once more divided in centers. GGzE Centre child and adolescent psychiatry is part of the division child and adult psychiatry, and offers help to children and adolescents (0 till 23 years old) and their parents or other raisers. Types of problems those children and adolescents deal with are severe kinds of eating disorders, ADHD, fear, behavioral problems, depressions, autism related disorders, psychosis or trauma related problems (www.ggze.nl).

The throughput times and waiting times W1, which is the time between application and first contact, of care delivery processes in GGzE Centre child and adolescent are undesirably high, and on average the clients wait longer than is allowed by the standard ('Treeknorm'). Joosten (2009) presented these results during the start meeting "improving care logistics" where managers and directors of GGzE

[1] Information with regard to changes and forces concerning GGZ is adapted from the Trend Report GGZ 2008. The trend report composed by the Trimbos Institute for the Ministry of Welfare exists out of three series, which are: part 1 Organization, Structure, and Financing; part 2 Entrance and Care Usage; and part 3 Quality and Effectiveness.

Centre child and adolescent psychiatry discussed about the emerging logistical problems and try to find solutions. A planned series of meetings together with resulting projects are based on the breakthrough method[2]. In order to get more insights into the problems, in previous years several actions have been undertaken by GGzE Centre research and development to map the current situation. However, since these analyses were mostly qualitative, insufficient insight has been gained with respect to the operational measures necessary for monitoring and controlling processes. Furthermore, managers and directors of the GGzE Centre child and adolescent psychiatry are of the opinion that more measures, especially about specific processes and process phases, are desired for managing their processes.

In order to solve this problem the following research question is formulated:

"Which method can be used to analyze data about care delivery processes in GGzE Centre child and adolescent psychiatry at a level that client flows can be identified and design solutions for logistical improvement can be developed?"

1.2 Scope

From the research question one can abstract that care delivery processes are the central issue of this master thesis project. In operations management terms Vissers and beech (2005) distinguish three logistic approaches which are: unit logistics, chain logistics, and network logistics. In this context a care delivery process should be approached as a chain.

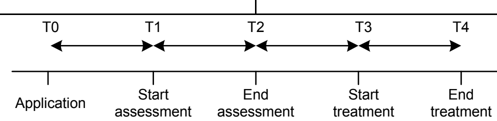
In section 2.2 of this report a more comprehensive explanation about the logistic approaches is given. For now some short definition about the approaches are stated in order to get enough understanding about the scope of the research project:

- A unit logistics approach is needed when aiming on aspects concerning resource utilization and workload control.
- The chain logistics approach focuses on the service level of a chain of operations.
- Network logistics combine the unit and chain perspectives. It draws on the notion that optimization of the service in the chains needs to be balanced with efficiency in the use of resources in the unit.

For a network logistics approach, ideally all chains and all units need to be included. However, often this is far too complex. Therefore a chain logistics can be a good alternative, especially when improving the performance of the process for a single patient group (Vissers and Beech, 2005).

Table 1 Baseline measurement versus 'Treeknorm' (www.versnellingjeugdggz.nl)

Term baseline measurement	***Term Treeknorm***	***Treeknorm GGZ***
T0 – T1 Application – start assessment	Application waiting time	4 weeks / 80% within 3 weeks
T1 – T2 Start assessment – end assessment	Assessment waiting time	4 weeks / 80% within 3 weeks
T2 – T3 End assessment – start treatment	Waiting time for 1) Treatment ambulant 2) Treatment clinical or 3) Protective living	 1) 6 weeks / 80% within 4 weeks 2) 7 weeks / 80% within 5 weeks 3) 13 weeks / 80% within 8 weeks
T3 – T4 Start treatment – end treatment	*Not defined in Treeknorm*	



[2] The breakthrough method, developed in the United States and in the meanwhile applied in many countries, is meant to achieve breakthroughs in the scope of client orientation, safety, logistics, efficiency and quality in a short time period. Breakthrough projects focus on multiple disciplines related to a particular care process (Schouten et al., 2007; www.ihi.org).

Although we will discover that describing a care delivery process as a simple sequence is rather an unreasonable assumption, Table 1 offers an illustration of the four care process phases. Moreover this table shows the maximum waiting times, also called 'Treeknorm', which is a standard formulated by Dutch care providers in collaboration with insurance organizations. Unfortunately it is known that few organizations meet the 'Treeknorm'. Therefore GGZ providers started projects in which baseline measurements are evaluated on the 'Treeknorm'. At www.versnellingjeugdggz.nl one can find how several breakthrough projects aiming at reducing throughput times and waiting times are already successfully implemented at several child and adolescent departments of Dutch mental healthcare institutions.

1.3 Focus

In order to find solutions to the research question several methods and techniques could be applied. For the master thesis project applied at 'GGzE Centre child and adolescent psychiatry' there are a number of motives which determine the methods and technique used. Besides personal interests and professional knowledge gathered during the master education, there are several parties who contributed to the project and supplied valuable state-of-art research information. In this section these motives are discussed.

First of all, this master thesis focuses on improvement of mental healthcare processes. In order to improve healthcare delivery the concepts Care Programmes and Care pathways are introduced by Joosten, Bongers, and Janssen (2009) of GGzE Institute of Mental Health Care Eindhoven in collaboration with Tilburg University. In combination with other operational aspects of lean thinking, such as, patient-in-process analysis it is expected that those concepts will contribute to reducing throughput times and waiting times. In addition Linskens (2009) performed a master thesis graduation project at the GGzE Centre child and adolescent psychiatry, which aimed at providing improvements for reduction in access- and (sub)throughput-times for applied client by improving efficiency of processes. In her thesis the emphasis is on the client perspective, lean thinking and Route 1 (the first phase in the care delivery). Mental healthcare processes in general are described in section 2.1. In particular the concept care programmes and care pathways are discussed in section 2.1.1, and the process a client goes through at GGzE Centre child and adolescent psychiatry has been depicted in section 2.1.1.

From a general perspective, two main research areas can be considered in order to manage care delivery improvement projects. First, care delivery process improvement projects can be considered as so-called Business Process Management (BPM) projects. According to van der Aalst et al. (2007a) business process management is defined as 'supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving, humans, organizations, applications, documents and other sources of information'. BPM projects have a specific life cycle (see figure 1), which includes a number of the steps that should be taken to keep improving processes.

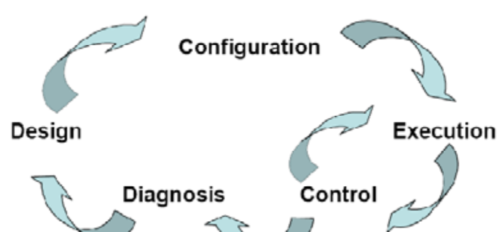


Figure 1 The BPM life-cycle (adapted from van der Aalst et al, 2007)

In particular, this thesis focuses on the control and diagnosis phases in which revealing weaknesses and monitoring of the process are the main issues. In the control phase the execution of the operational business process is monitored. The control part of the BPM system monitors on the one hand individual cases to be able to give feedback about their status, and on the other hand, aggregates execution data to be able to obtain the current performance of the workflow. In the diagnosis phase information collected in the control phase is used to reveal weaknesses in the process. In this phase the focus is usually on aggregated performance data and not on individual cases. The diagnosis information is providing ideas for redesign (e.g., bottleneck identification) and input for the analysis of redesigns (e.g., historic data) in the design phase (van der Aalst et al., 2007a).

Business Process Analysis (BPA) includes approaches like process mining and visual analytics. Process mining and visual analytics are data-based research approaches for process analysis that have been successfully implemented in hospital settings, in previous research projects at Eindhoven University of Technology. Riemers (2009) developed a data-based method for process analysis in healthcare using process mining and visual analytic tools. This method has been validated by Torres Ramos (2009). According to Torres Ramos (2009) the main idea of the method is that the combination of process mining and visual analytics could be a good option for getting relevant healthcare process information. These approaches appear to be good complements because process mining is a process driven approach which looks at the inside of the processes while visual analytics can help users to obtain clearer process insights. The tools used in the method for process mining and visual analytics are the ProM tool and the MagnaView tool respectively. Both approaches and tools are discussed in more detail in section 2.2.

The second main research area which is considered in order to manage care delivery improvement projects is health operations management (health OM). According to Vissers and Beech (2005) health OM is defined as 'the analysis, design, planning and control of all steps necessary to provide a service for a client'. In other words, health OM is concerned with identifying the needs of clients, and designing and delivering services to meet their needs in the most effective and efficient manner. Section 2.3 provides a theoretical background concerning relevant approaches, principles and techniques applicable to care delivery process improvements.

1.4 Research approach

In order to answer the research question depicted in section 1.1 a research approach has been established. The general methodology used is a 'qualitative research approach', since the main issue of the project is a developing a 'method'. According to Jonker and Pennink (2000) systematic searching new insights are the central issue when performing qualitative research. Therefore, data collection and data analysis take place at the same time. For assessing the research, transparency and proving insight will be more important than the reliability of the research. In other words, in case of qualitative research the main question is if the involved parties which are subject of the research also attach significance to the theoretical insights found. Since the project for "GGzE Centre child and adolescent psychiatry" also requires quantitative analyses, a quantitative approach is indispensable. Jonker and Pennink (2000) argue that outcomes of qualitative research can be tested by means of a quantitative research approach. With that, both approaches are complementary and not contradictory. Diagram of the qualitative and quantitative research methodology is depicted in appendix A.

The method of how to conduct the research is explained by means of a research framework. According to Jonker and Pennink (2000) a method supplies instructions about how to handle, based on a chosen methodology, and consists ideally of predefined steps which are provided with rules and prescriptions. The research framework developed in order to answer the central research question is depicted in figure 2. The framework represents the basic research topics and their relationships. Within the research framework there are three domains defined, these are:

- Initiation;
- Identification;
- Analysis;
- Design;
- Evaluation.

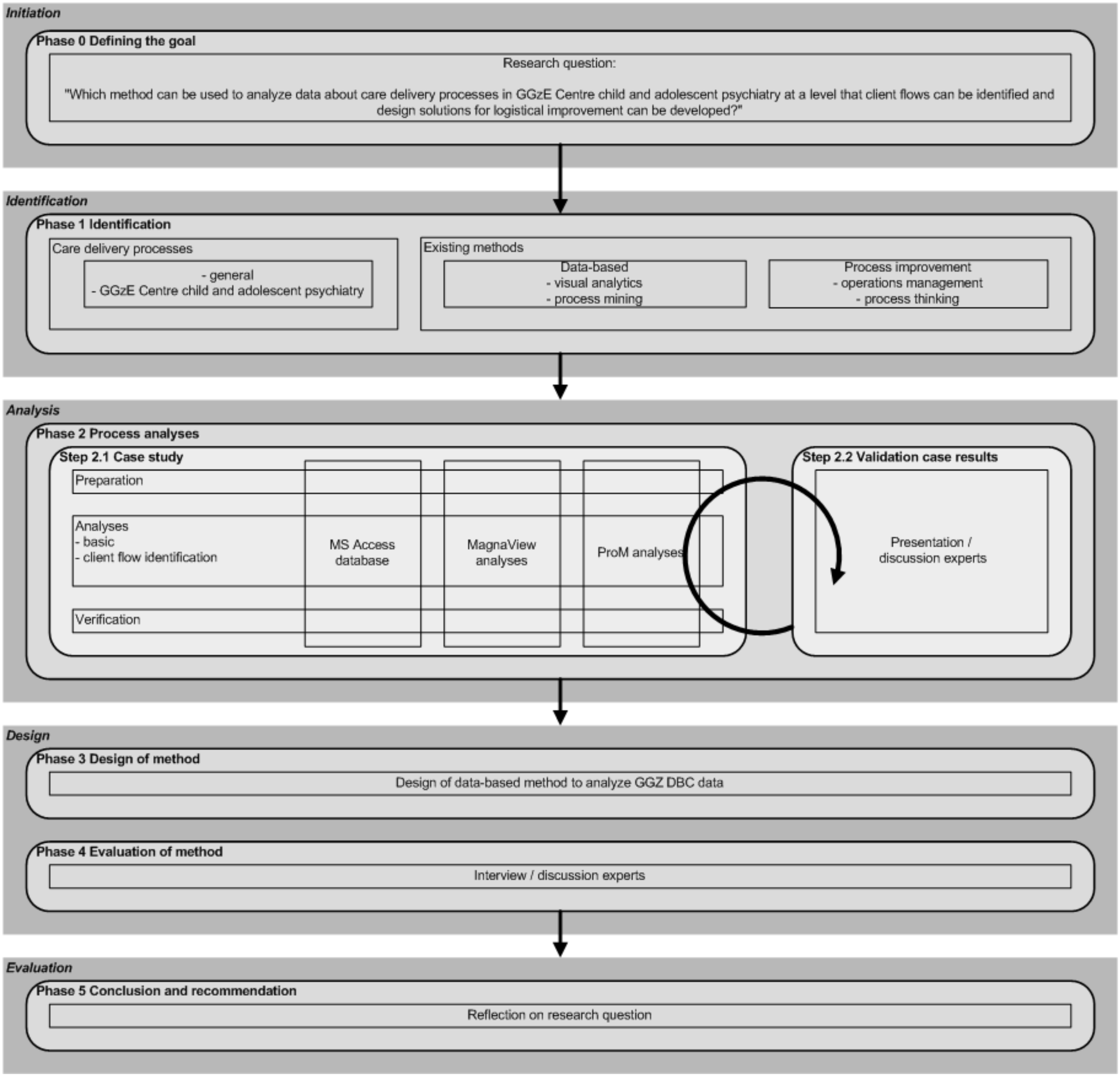


Figure 2 Research framework

The domains are further divided into project phases:

- Phase 0: Defining the goal;
- Phase 1: Identification;
- Phase 2: Process analyses;
- Phase 3: Design of method;
- Phase 4: Evaluation of method;
- Phase 5: Conclusion and recommendation.

The next step was to define smaller parts, the work packages (WPs), for which sub questions are defined. In figure 2 the work packages are depicted by small rectangles. Within this section a short description of all phases and their corresponding work packages is given. To start with: "Phase 0 Defining the goal"; which is done by means of creating a research plan. A clear problem definition with a research question that is embedded, relevant, precise, functional, and consistent, as it should be (Oost and Markenhof, 2002), is the main starting point. Figure 2 depicts the following research question:

"Which method can be used to analyze data about care delivery processes in GGzE Centre child and adolescent psychiatry at a level that client flows can be identified and design solutions for logistical improvement can be developed?"

In order to answer this research question first a study in order to identify the research setting and relevant existing methods should be performed; this is done in phase 1. In the research framework this is referred to as 'care delivery processes' and 'existing methods'. To start with the first, models prescribing mental healthcare processes and client flows in mental healthcare institutions should be identified. Furthermore, the theoretical background of DBC-data will be investigated, since this data type will be used during the actual process analyses step. Moreover, the prescriptions of care delivery processes in GGzE Centre child and adolescent psychiatry according to guidelines of GGzE will be established. After completion of this WP, it will be clear what already is prescribed about the specific care delivery processes, and how the process 'blueprint' looks like. Secondly, existing methods should be identified. For this master thesis project both a data-based method as well as process improvement approaches suitable for healthcare settings are identified. Those existing methods are of great interest for designing a method which can be used for analyzing data about care delivery processes in GGzE Centre child and adolescent psychiatry. When the theoretical framework is identified the next phase should commence.

Phase 2 consists of process analyses. In particular, the DBC-GGZ data about care delivery processes of GGzE Centre child and adolescent psychiatry have been analyzed during this phase. In order to do so, phase 3 consists of two steps which interact with each other on an iterative basis. Step 2.1 comprises a case study based on DBC-GGZ data. Therefore three main process steps should be executed, these are: preparation, analyses, and verification. Moreover, the three steps are similar for the application of the analyses tools, which are: MS Access (for database issues), MagnaView, and ProM. By means of step 2.2 the analyzed results should repeatedly being validated. This had been done by organizing presentations and discussions with managers and professionals of GGzE Centre child and adolescent psychiatry (K&J) and GGzE Centre research and development (O&O).

Based on a reflection of the results obtained during phase 1 and phase 2, a data-based method for analyzing DBC-GGZ data has been designed. This has been done during phase 3. In order to test if the method can be used for which it was designed, that is, data analysis at a level that client flows can be identified and design solutions for logistical improvement can be developed, an evaluation should be performed. This is depicted by phase 4 of the research framework. By means of testing the method on a number of criteria, the usefulness of the method had been determined. Furthermore, it is important to establish the usefulness of the method for practical aspects of GGzE.

Then to close the project a last phase should be completed in order to assess that the goals are reached. This phase is called "Conclusion and recommendation" and contains a reflection on the research question. Here will be concluded what the answer on the research question is and what the remaining research gaps / blanc spots are.

1.5 Outline

Within this last section of chapter 1 the content of the remaining of this report is stated. Chapter 2 starts with a theoretical background concerning improvement of care delivery processes by means of a data-based method. In section 2.1 first recent developments with respect to describing mental healthcare processes in general, and care delivery processes at GGzE Centre child and adolescent psychiatry in specific are described. With regard to data-based analysis of care delivery processes, section 2.2 discusses the approaches visual analytics and process mining. Furthermore the combination of both approaches by means of a data-based method for control and diagnosis in a healthcare environment developed by previous graduate students at the Industrial Engineering department of Eindhoven University of Technology is discussed. However the data-based method serves as a good starting point for diagnosis and control of mental healthcare process, a more purposive approach for logistical improvement is required. Therefore, in section 2.3 the approaches emerging from the health operations management domain will be discussed.

In chapter 3 the data-based method for mental healthcare process analysis is discussed. Typically, section 3.1 describes the design of the method. Within that section a small overview of the steps and their relationships is given. These steps are explained in more detail in the remaining of that chapter. In succession the following steps are discussed: build database, preprocessing, visual analytics and process mining (both including transformation, loading, analyses, and verification), filtering and clustering, and validation.

The data-based method is applied at DBC-GGZ data about care delivery processes in GGzE Centre child and adolescent psychiatry. The results of this case study are depicted in chapter 4. First the dataset specification are described in section 4.1. Then the results of process analysis are discussed. First the MagnaView analyses, with regard to the categories ‘process characteristics’, ‘bottlenecks’, and ‘process patterns’ are discussed. Secondly, the analyses obtained by ProM by means of process mining and process analysis plug-ins are described. Then the research is taken a step further in the direction of client group identification, which is explained in section 4.3. In section 4.4 the validation of the case results is disussed. And finally, section 4.5 deals with evaluation of the method. This master thesis report is closed with a conclusions and recommendations (chapter 5).

2 Theoretical background

This second section provides theoretical background related to data analysis and process improvement of care delivery processes in GGzE Centre child and adolescent psychiatry. Within this section three domains form the central focus of methods and techniques used in order to answer the research question. In section 2.1 (Dutch) mental healthcare processes in general are discussed. In addition, care delivery processes at GGzE Centre child and adolescent psychiatry in specific are described. In section 2.2 the process analysis approaches visual analytics and process mining are introduced. Both approaches are combined in a data-based method for control and diagnosis in a healthcare environment by previous graduate students at the Industrial Engineering department of Eindhoven University of Technology. This existing method forms the basic principle for the data-based method for mental healthcare analysis discussed in chapter 3. However, the data-based method forms a good starting point for control and diagnosis, this method does not serve an obvious connection towards logistical improvement. Therefore, in section 2.3 the domain health operations management will be discussed. In particular, this section presents a logistical approach for process improvement.

2.1 Mental healthcare processes

In this section the main characteristics of (Dutch) mental healthcare processes are described. In addition, it is explained how these processes should be approached in order to improve them. In mental healthcare a client with a demand for care applies at a care institute. Although it is not yet known what this demand implies, this is where the care delivery process starts. Joosten et al. (2008) state that mental healthcare processes are divided in two regularly repeating and overlapping phases:

- In the *specification phase* activities are aimed at choosing the right intervention from all available services, given the patient's condition and personal preferences to reach a desired outcome.
- In the *delivery phase*, the chosen intervention is carried out. Regularly, this intervention will be evaluated in the light of the desired outcome.

Joosten et al. (2008) argue that both care programmes (CPs) and integrated care pathways (ICPs) are needed to improve processes and quality in the mental health service specification phase and delivery phase. Furthermore Joosten et al. (2009) explain that this approach could be an appropriate instrument when implementing aiming at redesigning operational aspects of the care delivery process. The first subsection explains CPs and ICPs in more detail. Then the second subsection describes the care delivery processes at GGzE Centre child and adolescent psychiatry in particular.

2.1.1 Care programmes and integrated care pathways

Joosten et al. (2008) argue that the specification-delivery distinction is similar to the plan-do-check-act cycle of Deming. Together, activities in these phases must be designed to improve care quality and optimize delivery processes. Since there is much uncertainty during the specification phase a care programme (CP) approach, characterized by a network architecture, seems most appropriate. Care programming in GGzE can be best illustrated by means of two models shown in appendix B:

(i) The van Bokkem and van der Velde's (2003) process steps, which are used as a starting point for all admission and assessment activities in GGzE.
(ii) The care-plan cycle developed by Joosten et al. (2008), which in addition to admission and assessment activities also accounts for the treatment phase.

In the delivery phase it is assumed that a causal predictable relation between the process steps exists. Therefore, Joosten et al. (2008) argue that this phase can be approached with integrated care pathways (ICPs), which are characterized by a supply chain architecture.

According to Joosten et al. (2008) care programmes in the context of Dutch mental healthcare are defined as "all specified and coordinated activities and measures to deliver healthcare services or to reach certain effects in a specified target population. Each CP is described using a name, goal, target population(s), partners, organization, preconditions, activities and modules. CPs can be used on different levels, which are:

- *Theoretically*: empirical data, clinical experience and patient input are used to asses which goals ought to be attained.
- *Individually*: information about available care can influence decision making between professionals and patient and improve critical reflection.
- *Organizationally*: coordinating healthcare services (in and between organizations).

However, Joosten et al. (2008) argue that CPs do not focus on how to organize and deliver the chosen services most effectively. Therefore, another instrument is needed that also focus on improving delivery processes. This is where integrated care pathways (ICPs) make their commencement.

Joosten et al. (2008) define integrated care pathways by means of the definition of a clinical pathway, which is "a method for the patient-care management of a well-defined group of patients during a well-defined period of time". ICPs can be regarded as instruments that focus on quality improvement, and in particular on standardizing and improving delivery processes. Since ICPs contain a causal predictable relation between the process steps (otherwise it's not an ICP), Joosten et al. (2008) argue that ICPs can be regarded from supply chain point-of-view. ICPs start from a supply chain point-of-view that is most suited in situations where standardized condition-centered care has to be delivered. Keen at al. (2006) explain that condition-centered care should focus on a person's condition and provide evidence-based treatment and care. By meeting the assumption of low variance between process steps, the delivery process can be viewed as a series of pipes. Ideally, free-flowing pipes without interruption will be created. Here there exists a direct conceptual link to the use of standardized production processes, and in particular the concept "focused factories" which is discussed in section 2.3.3.

2.1.2 GGzE Centre child and adolescent psychiatry

Like the title and the research question of this report already presumes the project has taken place in the form of a business case. The business case was performed at GGzE Centre child and adolescent psychiatry. In this section, an overview of processes within GGzE Centre child and adolescent psychiatry is given. This overview is mainly based on information Linskens (2009) provided in her master thesis "Process analysis and improvement at GGzE".

Within GGzE Centre child and adolescent psychiatry the following care programs are executed:

- Autism Spectrum Disorders
- Parenthood Problems and Trauma related disorders
- Moderate Cognitive Disorders and Psychiatry
- Eating disorders
- AD(H)D: Attention Deficit (Hyperactivity) Disorder
- Anxiety Disorders
- Mood Disorders
- Psychoses
- Plural Behavior Disorders

Care programming development in GGzE started in 1995. The initial idea was to change the delivery of care from supply- to patient-driven (Joosten et al., 2008). Care programs are based on scientific knowledge, professional consensus, and experience-based knowledge of clients in the area of children- and adolescent psychiatry. Furthermore, these programs are based on education and development of children and adolescents in general (Linskens, 2009).

Besides its division in care programs, GGzE Centre child and adolescent psychiatry has been structured in different routes. According to Linskens (2009) there are four routes, each describing different processes executed by professionals. These four routes are depicted in figure 3. Organizing care in routes has been done in order to integrate activities around a patient. Furthermore, routes are better recognizable for clients, employees, and referrers. Features of routes consider differences in extend, working method, and expertise needed. Routes imply motion between, for instance, ambulatory and clinical care provision, forensic and non-forensic, and between adolescent care provision and GGzE. Subsequently, routes imply crossings where decisions and connections with the environment can be made, what facilitates integrated care. Moreover, routes contribute to the definition of care programmes and care pathways, more visible and every route is linked to integrated care partners and the necessary provisions (Linskens, 2009).

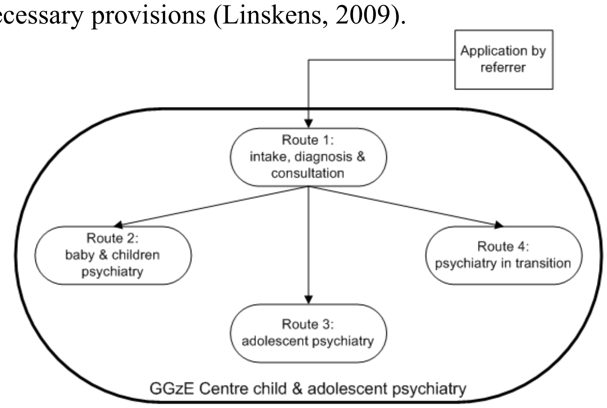


Figure 3 Organizing care in routes in GGzE Centre child & adolescent psychiatry (adapted from Linskens, 2009)

In figure 4 is shown that a potential client enters route 1 from the moment that a potential GGzE client has been applied by a general practitioner, pediatrician, or the Office for Child and Adolescent welfare (Bureau Jeugdzorg). After intake and a preliminary diagnosis have been performed, the client continues with either route 2, route 3, or route 4. The choice for a specific route depends on the age of the client and the nature of his/her psychological problems. Route 2 contains ambulant care for babies and children until the age of twelve. Route 3 includes care provision for adolescents in the age of twelve until twenty-one. And route 4 deals with adult-care; here care is provided for patients with eating disorders, traumas, and in case of parenthood problems the parents are involved as well (Linskens, 2009).

Another distinction is made on the bases of ambulatory care and clinical care (figure 4). Route 1 involves both ambulatory and clinical care, however for both types of care route 1 is performed in a different manner. Ambulatory care is provided to children and adolescents and in specific cases to adolescents with forensic background. Clinical care is provided in an adolescent psychiatric clinic and a clinic for orthopsychiatry.

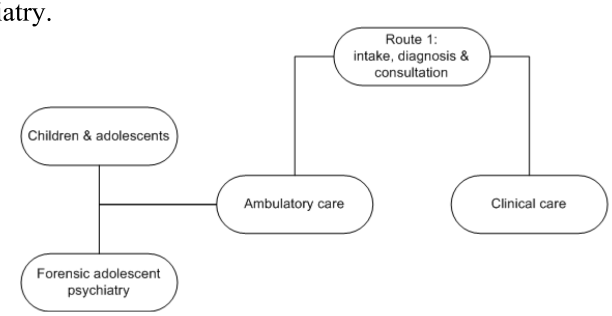


Figure 4 Distinction between ambulatory and clinical care (adapted from Linskens, 2009)

Since it was expected by directors of GGzE that route 1 causes most problems the research of Linskens (2009) focused mainly on that part of the process. By means of a SWOT-analysis the largest needs for improvements of route 1 are indicated, these are: (1) High frequencies of waiting lists, waiting times, and waiting systems; and (2) Professionals state that processes are performed too slow, everyone works for his own compartment, and ambiguousness exists in the structure of the organization: “Who is responsible for what?”

An overview of the main processes taking place during route 1 is depicted in figure 5. After the first phase, application, the potential GGzE client is placed on a waiting list for screening. During the screening phase the client's file is being examined by the PCP (Program Coordination Point), a multidisciplinary team. Subsequently, the client is placed on a waiting list for the intake. Depending on the type of suspected disorder and the complexity of the demand of the client, the intake is performed by only a SPN (Social Psychiatric Nurse), both SPN and a psychiatrist, or a GGZ-psychologist. Hereafter, the information derived from the intake is assessed by the professional who has performed the intake. Finally, during the PCP a preliminary diagnosis is defined and the urgency for care is determined. Next, the client is placed on a waiting list for research & diagnosis in one of the other routes Linskens (2009).

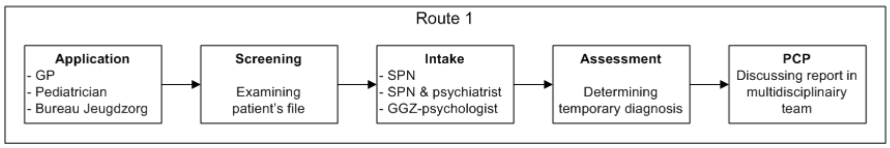


Figure 5 Processes within route 1 (adapted from Linskens, 2009)

2.2 Process analysis approaches

In order to analyze the care delivery process at GGzE Centre child and adolescent psychiatry, the process analyses techniques process mining and visual analytics will be used. These approaches have proven to be good complements when applied in healthcare environments due to the fact that the main purpose of process mining is to look inside of the processes while visual analytics focuses on presenting the process information in a clearer way. During his master thesis project Riemers (2009) developed a data-based method for process analysis in healthcare using process mining and visual analytic tools. This method has been validated by Torres Ramos (2009). According to Riemers (2009) and Torres Ramos (2009) process mining and visual analytics have been successfully applied in healthcare settings to obtain relevant process information. The tools used in for process mining and visual analytics are the ProM tool and the MagnaView tool respectively.

In the next chapter a data-based method for analyzing mental healthcare processes is described. Since this method is based on the existing approach developed by Riemers (2009) and Torres Ramos (2009), and thus also combines process mining and visual analytics, some preliminary theory about these approaches is presented in this section. In the first section a general overview of process mining and a description about the process mining tool 'ProM' is given. The second section deals with visual analytics, and the tool MagnaView. Finally, in the third section the method developed by Riemers (2009) and validated by Torres Ramos (2009) is described.

2.2.1 Visual analytics

According to Thomas and Cook (2006) visual analytics is a multidisciplinary field that includes the following focus area:

- Analytical reasoning techniques that let users obtain deep insights that directly support assessment, planning and decision making;
- Visual representations and interaction techniques that exploit the human eye's broad bandwidth pathway into the mind to let users see, explore, and understand large amounts of information simultaneously;
- Data representations and transformations that convert all types of conflicting and dynamic data in ways that support visualization and analysis;
- Techniques to support production, presentation, and dissemination of analytical results to communicate information in the appropriate context to a variety of audiences.

In the scientific domain, visual analytics focuses on the automatic construction of these visualizations. In this graduation project, visual analytics is used for the same purpose as that of Riemers (2009) and Torres Ramos (2009), that is, as the method for visual, interactive presentation.

The visual analytics tool used for the graduation project is MagnaView. According to Sogeler (2006) the goal of MagnaView is to give an almost unlimited number of visualizations of business data. It uses a special visualization method, called treemaps. Some visualization methods are good when a global overview of data is needed. Other visualization methods are suited when specific details are required. Treemaps provide a middle ground between these two by trying to combine both. Treemaps are also suited for visualizing large amounts of data.

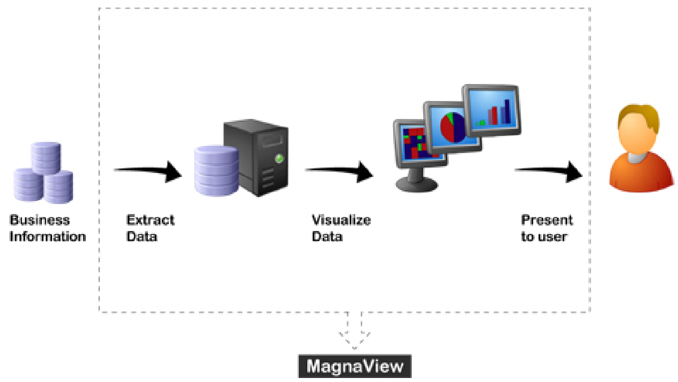


Figure 6 Data analysis using MagnaView (adapted from www.magnaview.nl)

According to Riemers (2009) MagnaView can be used for multiple purposes. The most important at the moment is its data analysis functionality (figure 6). MagnaView does not use mining algorithms to visualize data but leaves mining to the user. This is accomplished by presenting large datasets in one and the same visual, interactive presentation. Riemers (2009) mentions several ways how analysts are able to interactively analyze data in a healthcare setting by means of MagnaView. First, the analyst can select useful data directly from the visualization. This enables the analyst to explore more information about the data and focus the analysis. Secondly, the analyst can use filters to filter out unnecessary data or to select a specific patient. Thirdly, interaction is possible in the form of zooming. The analyst can zoom in on data of one year or one particular specialist, making is easier to analyze the data.

2.2.2 Process mining

According the Mans et al. (2008) process mining aims at extracting process knowledge from so-called “event logs” which may originate from all kinds of systems, like enterprise information systems. Typically, these event logs contain information about the start/completing of process steps together with related context data (e.g. actors and resources). The goal of processes mining is to extract information (e.g. process models) from these logs. Typically, process mining approaches assume that it is possible to sequentially record events such that each event refers to an activity (i.e. a well-defined step in the process) and is related to a particular case (i.e., a process instance or care trajectory). Furthermore, some mining techniques use additional information such as the performer or originator of the event (i.e., the person/resource executing or initiating the activity), the timestamp of the event, or data elements recorded with the event (e.g., the size of an order).

The idea of process mining is to discover, monitor and improve real processes (i.e., not assumed processes) by extracting knowledge from event logs. Process mining techniques can be split into three categories (Aalst et al., 2007b; Mans et al, 2008; Alves de Medeiros and Weijters, 2009), these are the following:

(1) *Discovery*: Traditionally, process mining has been focusing on discovery, i.e., deriving information about the original process model, the organizational context, and execution properties from enactment logs. Techniques for discovery try to generate a model based on the event logs. This may be a process model, but also other models focusing on different perspectives, e.g. the control flow perspective, organizational perspective, and performance perspective, can be discovered using process mining. For example, there are approaches to extract social networks from event logs and analyze them using social network analysis. This allows organizations to monitor how people, groups, or software/system components are working together. Also, there are approaches to visualize performance related information, e.g. there are approaches which graphically show the bottlenecks and all kinds of performance indicators, e.g., averages/variance of the total flow time or the time spent between two activities.
(2) *Conformance*: Techniques for conformance checking aim at exposing the difference between some a-priori model (e.g., a Petri net describing the control-flow) and the real process observed via the event log. Conformance checking may be used to detect deviations, to locate and explain deviations, and to measure the severity of these deviations.
(3) *Extension*: Techniques for model extension take some a-priori model and project other information on it derived from the log, e.g., a Petri net can be extended by providing a decision tree for each choice in the system. This way data and performance aspects can be projected on some a-priori model obtained directly from the system or discovered through process mining.

Note that the method described in chapter 3 only applies the discovery technique, since this technique is most easily to understand and apply. Furthermore, this project is the first initiative to data analysis taken by GGzE; conformance and extension should be applied only then when process models are already discovered. At this point in time there are mature tools such as the ProM framework, featuring an extensive set of analysis techniques which can be applied to real-life logs while supporting the whole spectrum depicted in figure 7 (Mans et al, 2008; Alves de Medeiros and Weijters, 2009).

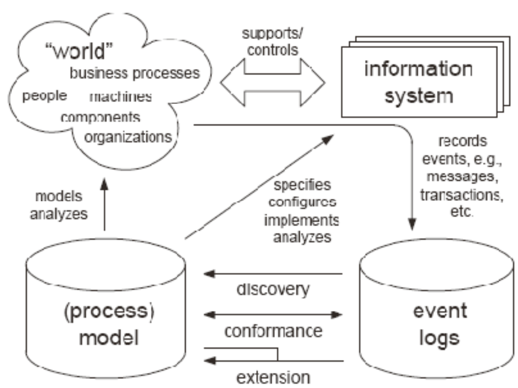


Figure 7 ProM framework (adapted from Alves de Medeiros and Weijters, 2009)

ProM is a generic open-source tool developed by a group of researchers at Eindhoven University of Technology, for implementing process mining tools in a standard environment (www.processmining.org). Yet, ProM has been applied to all kinds of processes in for example industrial settings, healthcare environments, and insurance and banking systems. ProM uses the Mining XML (MXML) format for its input logs. ProMimport is the tool which can be used for the extraction of these logs from all kinds of popular information systems. The ProM framework has been developed as a completely plug-able environment, which can be extended by simply adding plug-ins. The most interesting plug-ins are the mining and the analysis plug-ins. The architecture of ProM allows for five different types of plug-ins (Aalst et al., 2007b):

- Mining plug-ins, which implement some mining algorithms, e.g. mining algorithms that construct a Petri net based on some event log.
- Export plug-ins, which implement some "save as" functionality for some objects (such as graphs).
- Import plug-ins which implement an "open" functionality for exported objects.
- Analysis plug-ins which typically implement some property analysis on some mining results.

- Conversion plug-ins which implement conversions between different data formats.

The specific plug-ins included in the data-based method for mental healthcare analysis are described in the next chapter.

2.2.3 Data-based method for control and diagnosis in a healthcare environment

Previous graduation research projects of Riemers (2009) and Torres Ramos (2009), both graduated at the Industrial Engineering department of Eindhoven University of Technology, focused on designing and validating a data-based method for control and diagnosis in a healthcare environment. Although both projects applied in hospital settings, the phases defined in the method are regarded as a good starting point in order to identify client flows in care delivery processes in GGzE Centre child and adolescent psychiatry. Furthermore, it is expected that process related information can be easily obtained and interactively offered to users which in turn can use the information for logistical improvement such as throughput times and waiting times reduction.

The main advantage of the method developed by Riemers (2009) and validated by Torres Ramos (2009) is that it both utilizes process mining and visual analytics techniques. The combination of these techniques supposes complementary results due to the fact that process mining offers process related information by looking at the inside of the process while visual analytics can present this information in a clearer way. The tools proposed in the method for process mining and visual analytics are ProM and MagnaView respectively. Another way to take advantage of using the existing method is that hospitals as well as mental healthcare organizations in the Netherlands register their activities by means of the DBC (DiagnoseTreatment Combination, in Dutch Diagnose Behandel Combinatie) systematic.

The method developed by Riemers (2009) and validated by Torres Ramos (2009) proposed seven main steps, which are:

- Build database
- Introduction session
- Preliminary analysis
- Preliminary meeting
- 2nd analysis
- Final meeting
- Documentation

In order to test the usefulness of the method a number of criteria were set. These criteria are:

1. The results should be presented within limited time.
2. Process models should have a high fitness.
3. The approach should be positively evaluated by the medical specialists and managers.
4. The results should be simple to understand for the medical specialists and managers.
5. Interactive analysis should be possible.
6. The analysis should focus on certain aspects of the treatment process.

Note that for the GGzE project these criteria also will be used in order to evaluate the newly designed data-based method.

2.3 Health operations management

Although the process analysis approaches mentioned in the previous section are promising with regard to process analysis (i.e. control and diagnosis), they are not yet embraced when design solutions for logistical improvement should be developed. In order to extract diagnostic information which can be used for providing ideas for redesign, an extension with operations management approaches, and in particular a logistical approach is required. According to Vissers and Beech (2005) health operations management (OM) is defined as “the analysis, design, planning and control of all steps necessary to provide service for a client". Within the first subsection a logistical approach for healthcare process improvement developed by Vissers (2006) will be discussed. In the second section the concept of iso-process patient grouping is discussed, which is the first step of the logistical approach and serves as a starting point when analyzing complex healthcare processes. Thirdly, the more general process improvement approach focused factory is discussed which is in particular relevant since it is a widely tested concept in industry which emerges as a model for designing integrated care pathways and homogenous patient groups. Here, there is first explained how healthcare can be linked to OM.

Unfortunately, most health OM literature focuses on hospital settings and not on mental healthcare processes. However, Vissers and Beech (2005) argue that processes in hospitals are most complex, have a shorter throughput time and a higher volume compared to other sectors such as mental health, and therefore, one could state that hospitals are a perfect ground for health OM. Moreover, Vissers and Beech (2005) state that the principles of the hospital examples can nevertheless be easily translated to other healthcare sectors. In the same context Hall et al. (2006) have applied queueing theory for the study of health care delay. They argue that, when respecting health care's unique features, reducing health care delays is similar to the efficient coordination of work in a factory. According to Hall et al. (2006) healthcare delays can be reduced through awareness of best practices, application of quantitative methods and a commitment to change.

2.3.1 A logistical approach for process improvement

Vissers (2006) developed an operations management approach to process improvement and applied that to the cardiology patient flow in hospitals. Although this is a hospital application, the steps taken can be generalized to other healthcare settings in which the patient flow is issue of concern. The approach consists of five steps which are the following:

- The first step of Vissers' (2006) approach is to identify iso-process patient groups, for which a specific organization of services is developed. In this step patient groups and the different trajectories followed by patients within a patient group should be identified. The concept of iso-process patient groups is further explained in section 2.3.2.
- The second step is to describe these processes in a way that allows analysis of the service and resource use impacts of processes.
- The third step is to define a production control per patient group, taking into account the characteristics of the process considered.
- The fourth step involves the setting of objectives for the performance of the process to enable its monitoring.
- The fifth and last step is regarding the responsibility for process management in hospitals. Vissers' (2006) argues that medical specialists need to take up the responsibility for process management in order to make improvements process sustainability.

In order to apply the method three main principles should be understand, which are: the distinction between logistics of units, chains, and networks; the framework for production control; and homogeneous process patient grouping. The distinction between logistics of units, chains, and networks and the framework for production control are briefly explained below. Homogeneous process patient grouping, which is the first step of the method, is in particular interesting in combination with data-analyses, and will therefore be discussed in more detail in the next section.

Logistic approaches

Vissers and beech (2005) distinguish three logistic approaches, which are: unit logistics, chain logistics, and network logistics. Since the focus of this thesis is on care delivery process, the client flow, or the flow of a patient (group), the concepts of chain logistics is regarded as most important. When aiming on aspects concerning resource utilization and workload control a unit logistics approach is needed. The chain logistics approach focuses on the service level of a chain of operations. Network logistics combine the unit and chain perspectives. It draws on the notion that optimization of the service in the chains needs to be balanced with efficiency in the use of resources in the unit. For a network logistics approach, ideally all chains and all units need to be included. However, often this is far too complex, especially for a change to improve the performance of the process for a single patient group. Therefore a chain logistics can be a good alternative, especially when improving the performance of the process for a single patient group (Vissers and Beech, 2005).

According to Vissers and Beech (2005) supply chains represent a series of different operations (undertake in different units) for the same type of product. The chain perspective is represented by patient groups. The focus of this perspective is on the total process of the patient, using different units on their journey through for example a hospital. The chain perspective strives to optimize the process according to some targets, which all relate to the time dimension. Typical targets are: short access time, short throughput time and short in-process waiting times. The prime objective of the chain perspective is to maximize the service level for patients belonging to a certain patient group. As the focus is on the one patient group considered, it is difficult to look at the efficiency of the chain in terms of use of resources. Resources are, in general, not allocated to patient groups, but to specialties. Efficiency issues therefore, can only be considered at the level of flows from all patient groups belonging to the specialty. This is where unit logistics or network logistics should be considered (Vissers and Beech, 2005).

A framework for logistical control

According to Vissers' (2006) the third step in the approach to process improvement is to define a production control per patient group, taking into account the characteristics of the process considered. In order to position 'production control per patient group', first a definition of production control is given. Thereafter, the framework for planning and control of hospitals is described.

A formal definition of production control defined by Bertrand and de Vries (2005), is the following: "the design, planning, implementation and control of coordination mechanisms between patient flows and diagnostic & therapeutic activities in health service organizations to maximize output/throughput with available resources, taking into account different requirements for delivery flexibility (elective/appointment, semi-urgent, urgent) and acceptable standards for delivery reliability (waiting list, waiting times) and acceptable medical outcome".

The framework for production control of hospitals of Vissers et al. (2005) deals with the balance between service and efficiency at all levels of planning and control. The figure in appendix C shows the hierarchy, spanning from long-term strategic planning issues at the top levels to short-term control issues at the bottom level. The framework shows that every level needs a horizontal control mechanism to match patient flows with resources and that vertical control mechanisms are required to set the targets for lower levels (feed forward) or to check whether activities develop within the boundaries set by higher levels (feedback).

Though the planning framework seems to be working only top down, the need for each level and the requirements for coordination are established bottom-up (Vissers, 2006). At the lowest level, individual patients are coupled to resources in the day-to-day scheduling. This level in the framework is called 'patient planning and control'. The way patients are operationally scheduled needs to be governed by rules established at patient group level. This level is called 'patient group planning and control'. To allow for the planning of a patient group resources need to be allocated, taking into account the availability of specialists and personnel. This level is called 'resources planning and control', and includes also the time-phased allocation of resources. The level of resources required results from the annual patient volumes contracted, and the service and efficiency levels targeted for. This level is called 'patient volume planning and control'. Finally, the volume level is governed by the strategic planning level, where, for instance, decisions are taken about which resources need to be shared or not. This level is called 'strategic planning'. At this level there is no control involved (Vissers, 2006).

2.3.2 Iso-process patient groups as business units

In addition to the logistic approaches and the systematic matching of demand and supply at different levels of planning mentioned in the previous section, Vissers (2006) states that there is an important third feature of the approach to process improvement, that is, the consideration of iso-processes as basis for production control of healthcare processes. Iso-process grouping is a way of classifying clients according to the trajectory that clients follow through their journey.

Given that processes or chains generate a service of a client, the focus for product classifications is driven by the requirements of the client. In particular, clients want a service that is efficient (for example, unnecessary delays in treatment are avoided) and effective (for example, evidenced based practices are used). In turn, the achievement of these goals is likely to increase levels of client's satisfaction. In order to plan and monitor the efficient and effective delivery of the products towards the client, operations managers want a product classification. According to Vissers and Beech (2005) iso-process groups as business units implies that patient groups are distinguished fulfilling the criteria (homogeneous in terms of process and market performance). Homogeneity in terms of market performance implies similar criteria for urgency, acceptable waiting times, etc. Homogeneity in terms of process implies that the patients within the product group use the same constellation of resources. However the overall amount of resources used by patients within the group may vary considerably, a fact that would need to be allowed for when planning capacity requirements. This iso-process grouping makes a logistics approach different from an economics approach (iso-resource grouping) and a medical approach (iso-diagnosis grouping). Vissers (2006) argues that from an operations management perspective, a product classification somewhere between these two "traditional" approaches seems to be required.

Vissers (2006) explains that the first attempts to define hospital products from a managerial perspective can be credited to Fetter and his colleagues (1983). They developed the DRG-system (diagnosis related groups) to classify all diagnoses into groups of diagnoses that are recognizable for physicians and homogeneous in terms of use of resources. In the Netherlands the Diagnosis Treatment Combination (Diagnose Behandeling Combinatie - DBC), which is comparable to the DRG-system, has been introduced. The key element of the DBC-system is that the total treatment trajectory of a client will be reimbursed, instead of the separated treatments. This way of financing is termed as product financing, where the 'product' is the total treatment trajectory belonging to a demand for care. In order to enable product financing the products, or treatment trajectories, should be defined. This definitions in the DBC-systematic are composed of two parts: the classification of the demand of care (in terms of diagnosis, the occasion of demand of care – regular or crisis – and the sort of demand – admission or not) in combination with the type of care profile (the activities which are done in order to meet the demand of care and the time spend on that activities) (van Hoof et al., 2008).

Ideally, in accordance with the DBC systematic, treatment guidelines should be leading for the interpretation of the care profile towards a certain demand of care. However, in practice, also in case of comparable demands of care, major differences between individual treatment trajectories exists. So, this is for the goal of the DBC systematic – the establishment of national, uniform treatment units – not suitable. In the GGZ one has chosen to first make an elaborated (administrative) analysis of the usual practice, and thereafter define a limited amount of product groups on the basis of a clustering of all existing trajectories. This has resulted in 92 ambulant product groups, 23 clinical product groups and 50 residence groups. The product groups are formulated in such a way that every treatment trajectory fits in exactly one product group. Furthermore, the product groups are internally as cost homogeneous as possible (van Hoof et al., 2008).

Although Vissers (2006) states that product groupings such as DRGs were primarily developed to support the financial reimbursement of hospitals rather than to support the planning and management of health care chain, they are regarded to have relevance to operations management. Since there exists a direct relationship between DRG cost and the efficiency with which resources are used within a DRG. Hence, there are parallels between the analysis of DRG costs and the efficient planning of care within process chains. Furthermore, Vissers (2006) proposes that it might be possible to generate product groups because the care of the patients covered can be regarded as being delivered in a 'focused factory': a business unit concept. This concept will be discussed in the next section.

To conclude, Vissers (2006) states that using iso-process groups as business units implies that patient groups are distinguished fulfilling the criteria (homogeneous in terms of process and market performance), that the volume of the patient flow is sufficient to allow for a specific production control, that the trajectories within these groups are described, that production control for each of the patient groups is defined and that the responsibility for managing the patient group is clarified.

2.3.3 Focused factory

Within this section the emerging process improvement approach focused factory is discussed. The focused factory concept is relevant in this context since it is a widely tested concept in industry which emerges as a model for designing integrated care pathways (Joosten et al., 2008) and homogeneous patient groups (Bertrand and de Vries, 2005). Ultimately, this management approach is expected to improve care delivery services in the mental healthcare sector.

Bertrand and de Vries (2005) describe that the focused factory concept developed by Skinner (1974), entails the idea that operational processes should be designed to support optimally the production and delivery of a homogeneous group of products or services. Homogeneity refers to the quality and requirements for the products or services in the market and the resources needed for their production. The essence of a focused factory can be found in the way in which the various resources in the factory are coordinated in order to achieve the required operational performance. The larger the variety in products, in services or in performance requirements is, the larger the required variety in resources and modes of operation will be and, as a result, more effort will be needed to coordinate the resources.

The large variety in products, services and resources will also result in less opportunity for learning, which takes place with the repeated execution of similar processing steps and repeated interaction with similar customers (Bertrand and de Vries, 2005). This learning effect is also described by Porter and Teisberg (2004), who state that numerous studies show that when physicians or teams treat a high volume of patients who have a particular disease or condition, they create better outcomes and lower costs. This phenomenon exits because the more experience physicians and teams have in treating patients with a particular disease or condition, the more likely they are to create better outcomes – and, ultimately, realize lower costs. By performing particular procedures over and over, teams increase their learning opportunities and thereby reduce mortality rates. The variety problem is also captured somewhat by Hopp and Spearman (2000) who argue that the main idea behind focused factories is that plants can do only a few things very well and therefore should be focused on a narrow range of products, processes, volumes, and markets.

Here we come to the main question: How can the focused factory concept be applied in healthcare organizations? Bertrand and de Vries (2005) state that hospitals traditionally are focused on the groups of specialties that are delivering their services to patients. This is not an approach based on the principle of homogeneity, because generally there is a large variety in resources needed for serving the patients of one specialty: simple (single resource) and complex (multiple resources), short and long stay, variation in the sequence of operations, etc. No difference in quality is applied, since in a healthcare environment everyone expects state-of-art quality. However, differences in services required can be a useful difference to be applied to differences in required delivery time (e.g. emergency cases were access time should be zero).

However, hospitals more and more focus on patient groups that are homogeneous in term of resources needed. Thus far, this principle is applied to specific diagnostic groups that cover only a small part of the total patient flow in a hospital. Furthermore, the principle is not applied to the whole service chain, from first visit to end of treatment, but only to a part of it. However, it can be possible to apply the principle of a focused factory for specific phases between decoupling points in the service of the patient flow. For many diagnostic groups, the process can be split into two main service phases: e.g. specification and delivery in mental healthcare organizations (section 2.1.1). The specification phase has different characteristics from the delivery phase: more uncertainty in demand, more variety in resources required, less predictability in the activities to be performed. For some patient flows the specification phase will be short and clear; for others, a step-by-step or sometimes iterative search process is needed. For this reasons the principle of focused factory tend to be more relevant to the delivery phase of patient care. According to Bertrand and de Vries (2005) the focused factory concept has shown to be successful for patient groups:

- With a predictable process, after the specification, and after a treatment plan is set up;
- With a low variety in the delivery processes;
- With common requirements in quality and service;
- That are homogenous in resource requirements;
- That do not require high flexibility.

The conclusion it that the focused factory concept is at least partially applicable in healthcare organizations:

- To a part of the total service chain, between well-defined decoupling points;
- To specific aspects, such as service, of the total set of requirements to be met;
- Processes should be transparent and defined in such a way that they can be analyzed in terms of their homogeneity.

So there should be more information for grouping patient flows from this point of view. However, for several reasons, such as quality assurance, efficiency, computerizing and process monitoring, operational processes are being more and more explicitly defined. Therefore, Betrand and de Vries (2005) expect that the focused factory will gain in applicability. Operations management will then be less complex, since the total patient flow, with a high degree of variation, will be split up into phases of care for homogeneous patient groups, resulting in reduced complexity and improved performance.

3 Data-based method for mental healthcare process analysis

Within this third section a data-based method for mental healthcare process analysis is discussed. First the design of the method, serving as a general overview, is introduced in section 1. Then the several steps included in the method are described in detail in the following sections. Section 3.2 depicts instructions for building the database, thereafter preprocessing is discussed in section 3.3. Then section 3.4 explains how visual analytics can be performed by means of MagnaView analyses, and the preparation steps needed in order to perform these analyses. In a similar way section 3.5 explains how process mining can be performed by means of ProM analyses, and the preparation steps needed in order to perform these analyses. Then the application of filtering and clustering is discussed in section 3.6. And finally, validation of the results obtained by the method is described in section 3.7. An application of the method by means of a case study at GGzE Centre child and adolescent psychiatry is discussed in the next chapter.

3.1 Design of method

Within this first section the design of the data-based method for mental healthcare process analysis is discussed. The design is graphically represented in figure 8. The method is to a large extent based on the method of Riemers (2009), but differs in two important aspects: (1) for this method mental healthcare process data instead of hospital process data has been used; (2) where Riemers (2009) typically approaches a preliminary analysis and executes one iteration, the model discussed here attempts to prescribe the required steps by means of a system approach (Hopp and Sprearman, 2000), allowing for more than one iteration. Typically, the method is designed in order to perform a case study which starts with initiation and ends with closure, like with projects in general. The case study at GGzE Centre child and adolescent psychiatry is described in the next chapter. Within this chapter the several steps depicted by means of diamonds at the execution, verification, and preparation activities, are described. Each of these activities refer to a (sub)section in this chapter. However, first an overview of the method is given below figure 8.

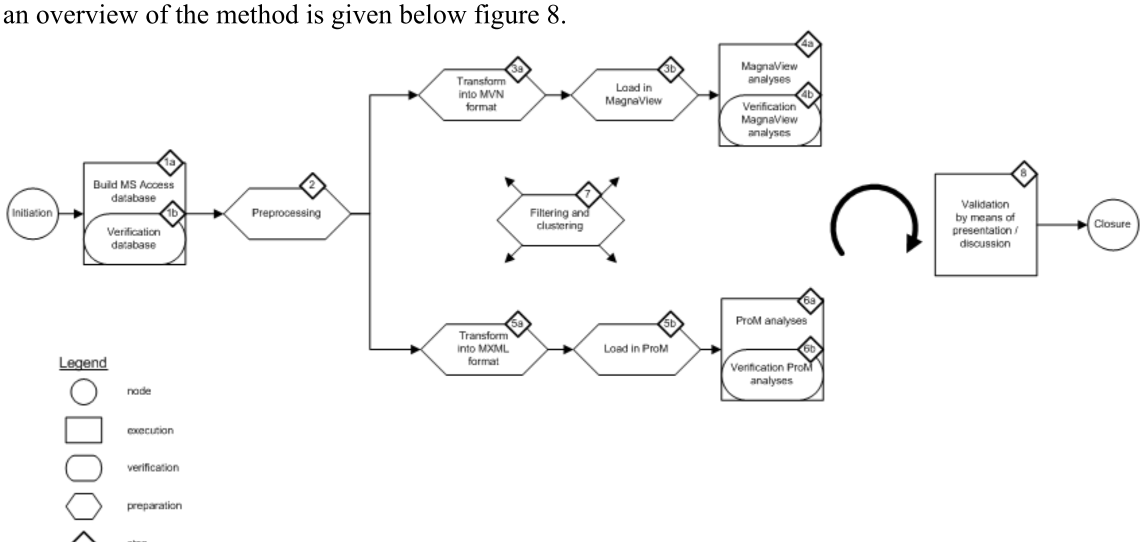


Figure 8 Data-based method for mental healthcare process analysis

First, it should be remarked that the model in figure 8, can be regarded as system analysis, or system approach described by Hopp and Spearman (2000). In particular, Hopp and Spearman emphasize the concept of iteration, which is needed when analyzing real world systems and describing this in an analog world (i.e. model). Furthermore, they stated that both verification (i.e., checking the logic of the model) and validation (i.e., comparing the model results to reality) are needed. Moreover, model validation involves repeated iteration between the modeling and observation aspects of the analysis, and should take place throughout the study (Hopp and Spearman, 2000). Iteration in figure 8 is depicted by the two-headed arrow.

The first step of the data-based method is to build the database by means of MS Access. In order to check if data is correctly loaded in the database a verification step is needed. Step 1a and 1b are described in section 3.2. When the database has been build and before one can start with process analyses by means of ProM and/or MagnaView, a preprocessing step needs to be done. This step is discussed in section 3.3. Then the user can choose to either perform analyses by means of MagnaView or by means of ProM, both having their own advantages and disadvantages. However before the actual analyses could be performed both tools require data transformation and loading steps. Furthermore, the analyses performed should again be verified. The steps of the MagnaView branch are 3a, 3b, 4a, and 4b and are discussed in section 3.4. Steps 5a, 5b, 6a, and 6b are described in section 3.5 'Process mining'.

The results obtained by MagnaView and/or ProM analyses should be validated by involved parties, i.e. managers and professionals of GGzE. In order to test whether the results of the analysis are understandable, relevant in order to analyze care delivery processes, and contribute to future process improvement, a number of presentations are performed. During these presentations managers and professions were able to discuss the results and come up with suggestions in order improve the data-based analysis. The validation step is discussed in section 3.7. In particular, validation leads to (new) filtering and clustering activities, which, depending on the nature of filtering/clustering, brings out repetition of preparation and/or execution activities. Filtering and clustering is discussed in section 3.6. Moreover, filtering and clustering is depicted in the centre of the method, since it plays a key role with respect to identification of iso-process patient groups, which is the first step to process improvement defined by Vissers (2006).

In addition should be stated that when applying the method the first time, all steps need to be performed in order to get the advantage of combining visual analytics and process mining. After a validation step the researcher can chose to skip steps and to follow only one of the analysis approaches.

Besides validation of the analyses, there is also the need to evaluate the usefulness of the method. Evaluation includes, among other things, the criteria set by Riemers (2009) stated in section 2.2.3. Evaluation of the method has been done during the case study at GGzE and therefore will be discussed in the next chapter, section 4.5.

3.2 Build database

Within this section a number of topics concerning the first step of the method will be discussed, these are: DBC-GGZ data files, building steps, additional data specifications, and verification of MS Access database.

3.2.1 DBC-GGZ data files

The first step is to design and construct a database in MS Access. Input for this database are the DIS (DBC information system) files which are used for GGZ-DBC registration. In DBC registration the reference (when available), the DBC trajectory, the care trajectory, care type, starting date, insurance information, all stated diagnoses, and all performed activities are registered during a care trajectory (Bruys et al., 2008). DBC data is delivered to DIS on a monthly base, and is combined by means of zip files. Each zip file contains the following text (.txt) files:

- dbc_traject.txt (DBC trajectory)
- diagnose.txt (diagnoses)

- geleverd_zorgprofiel_dagbesteding.txt (delivery careprofile day spending)
- geleverd_zorgprofiel_tijdschrijven.txt (delivery careprofile timekeeping)
- geleverd_zorgprofiel_verblijfsdagen.txt (delivery careprofile days of stay)
- geleverd_zorgprofiel_verrichtingen.txt (delivery careprofile operations)*
- overige_verrichtingen.txt (remaining operations)*
- pakbon.txt (packing list)
- patient.txt (patient)
- zorgtraject.txt (care trajectory)

* Files are empty.

3.2.2 Building steps

In order to design and construct a database, to import data, and to make this data ready for use five building steps are formulated. These are described below.

Step 0: Design database architecture
The first step which needs to be done in order to construct a database is defining import specifications in MS Access. The import specifications should be based on "Standaard voor DIS Gegevensaanlevering DBC door GGZ zorgaanbieders" (Buys et al.,2 008). In this document all attributes, description of the attributes, possible values, data type, length, starting position, ending position, constraint, and attribute type (primary / foreign key) are defined. After defining the import specifications, the tables and relationships between the tables can be constructed in MS Access.

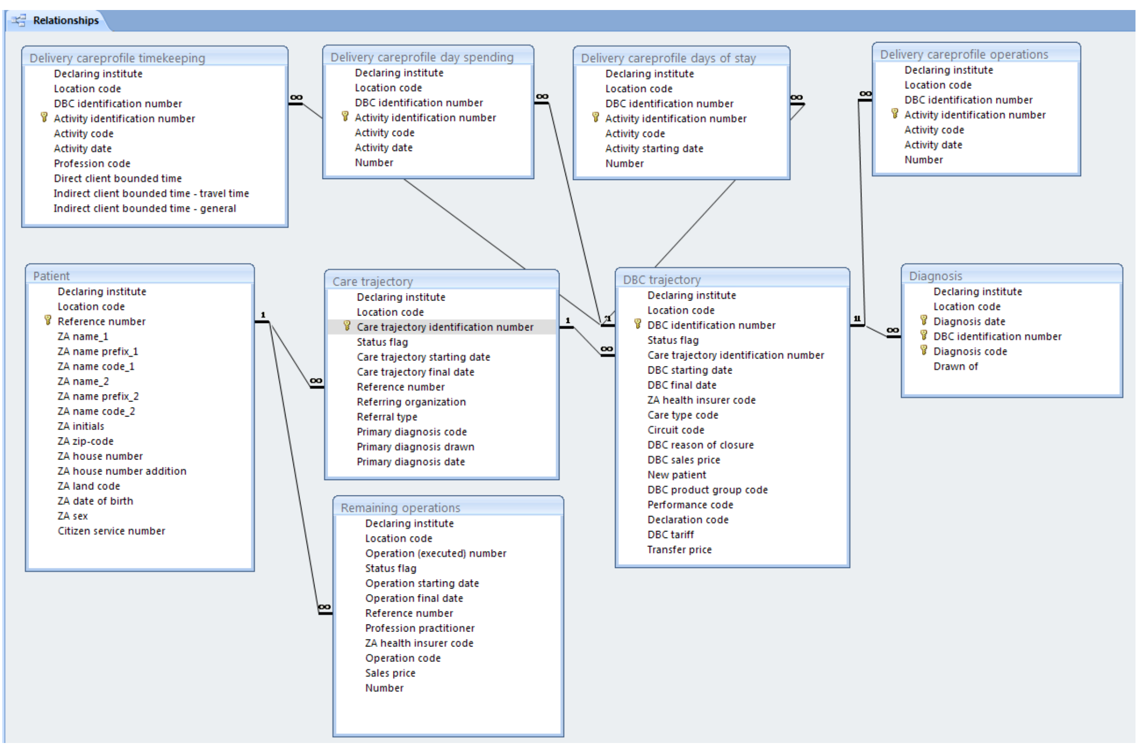


Figure 9 MS Access DBC-database architecture

Figure 9 depicts the tables and the relationships between the tables. To start on the left side, one can see that a patient has a unique 'reference number' which is the primary key of that table. For a patient one or more care trajectories are defined, this depends on whether more than one primary diagnoses are drawn. Since there is no DBC-GGZ data available for filling the fields in 'remaining operations', this table can be left out of consideration. Each care trajectory has a unique care trajectory identification number, which is the foreign key in the table 'DBC trajectory'. A care trajectory can have one or more DBC trajectories. This can be explained by the fact that the duration of a DBC trajectory is maximum one year, although a care trajectory in mental healthcare lasts often more than one year. Again a DBC trajectory has its own unique identification number. Then a DBC trajectory can have one or more connected diagnoses. The uniqueness of data in the 'diagnoses' table is maintained when the combination of 'diagnosis date', 'DBC identification number and 'Diagnosis code' is unique. Furthermore, there are four 'delivery careprofile' tables linked to a DBC trajectory. To start with the left one: a DBC trajectory can contain zero or more activities which are defined in 'Delivery careprofile timekeeping'. Each activity has again a unique identification number. Furthermore, each activity has an activity code (determining the type of activity), an activity date (date of execution), a profession code (determining which employee type the activity performed), and a duration which can be direct client bounded time or indirect client bounded time (which is further divided into general time and travel time). GGzE has also clients who require care delivery in the forms of 'day spending' activities or 'days of stays' activities. Here again holds that a DBC trajectory can contain zero or more activities in 'Delivery careprofile day spending' or 'Delivery careprofile days of stay', and that each activity has its own unique identification number. In comparison with general activities the clinical activities do not contain any profession (since there is no originator), and the duration is expressed in number of days instead of duration in minutes. The data fields of 'Delivery careprofile operations' are empty and therefore left out of consideration.

Step 1: Import data

After constructing the database, the DBC data need to be imported. Therefore, first some new text files should be made. For each text file category (i.e. patient, care trajectory, DBC trajectory, etc) a new text file should be made in which all separate files (of all months) are copied in reverse chronological order. This has to be done in order to force MS Access to import most recent data first. The new text files can then be used to import the data in MS Access. Furthermore, during the case study, it appeared that some 'final dates care trajectory' were missing in the original files. By means of queries these missing final dates should to be added to the database. After this step all available data is imported in the MS Access database.

Step 2: Remove flags (V)

In order to prepare the DBC data for further analyses, the flags (Vs) should be removed. These status flags are defined as an attribute in the tables 'Care trajectory' and 'DBC trajectory'. Removal of Vs is an action prescribed by Buys et al. (2008) in "Standaard voor DIS Gegevensaanlevering DBC door GGZ zorgaanbieders".

Step 3: Filter data GGzE Centre child and adolescent psychiatry

Since the data analyses only should cover processes in GGzE Centre child and adolescent psychiatry only DBC trajectories with 'circuit code' 4 and 7 should be kept, which are defined as 'Kinder & Jeugd' and 'Forensisch jeugd', respectively. All other codes refer to other centers of GGzE and therefore accessory data lines should be remove from the database.

Step 4: Remove unmatched records

Due to removal of inappropriate DBC trajectories in step 3, the tables 'Care trajectory' and 'Patient' now contain some unmatched records. These records should be removed in the following order, and by means of the following steps:

a. Remove care trajectories - care trajectory identification number

1. "Find Unmatched Query Wizard"
    - i. Fields in table "Care trajectory": Care trajectory identification number
    - ii. Fields in table "DBC trajectory": Care trajectory identification number
2. Choose option "Delete" in Design Query tools, and use SQL function to formulate which records should be deleted

```
DELETE [Care trajectory].[Care trajectory identification number]
FROM [Care trajectory]
```

```
WHERE (([Care trajectory].[Care trajectory identification number]) In (SELECT [Care trajectory].[Care trajectory identification number]
FROM [Care trajectory] LEFT JOIN [DBC trajectory] ON [Care trajectory].[Care trajectory identification number] = [DBC trajectory].[Care trajectory identification number]
WHERE ([DBC trajectory].[Care trajectory identification number]) Is Null));
```

3. Open 'table' view of Delete query and delete unmatched cases

b. remove patients - reference number

1. "Find Unmatched Query Wizard"
   i. Fields in table "Patient": Reference number
   ii. Fields in table "Care trajectory": Reference number
2. Choose option "Delete" in Design Query tools, and use SQL function to formulate which records should be deleted

```
DELETE [Patient].[Reference number]
FROM [Patient]
WHERE (([Patient].[Reference number]) In (SELECT [Patient].[Reference number]
FROM [Patient] LEFT JOIN [Care trajectory] ON [Patient].[Reference number] = [Care trajectory].[Reference number]
WHERE ([Care trajectory].[Reference number]) Is Null));
```

3. Open 'table' view of Delete query and delete unmatched cases

After this fourth building step the database is ready to use.

3.2.3 Additional data specifications

Other data which can be added to the database described in the previous section, contains attributes from the code lists (CL codelijst) defined by the DBC systematic. The code lists offer more specified and categorized information about the data elements. The following revised code lists for 2009 are available for GGZ:

- CL_AARD_DELICT2009.xls
- CL_ACTIVITEIT2009.xls
- CL_BEROEP2009.xls
- CL_CIRCUIT2009.xls
- CL_DBC_TARIEF2009.xls
- CL_DIAGNOSE2009.xls
- CL_GEVAAR2009.xls
- CL_PRODUCTGROEP2009.xls
- CL_REDENSLUITEN2009.xls
- CL_ZORGTYPE2009.xls

As an example the attributes of CL_ACTIVITEIT are depicted in appendix D. In this table there is an unique activity code defined, which is 'CL_ACTIVITEIT_CODE'. This code corresponds with the activity codes in the database. Linking these two offers the possibility to link other elements from the code lists to the database. In this way more specifications can be added to the attributes in the database. In the analyses phase, these specifications can be used for filtering, categorization or clustering activities.

3.2.4 Verification MS Access database

Verification of the MS Access database could be done in several ways. For the case study at GGzE the most important approach of verification was the construction of the database in parallel with construction of the same database by the GGzE project manager care logistics management. Together we learned from mistakes, helped each other with MS Access uses, and were twice as critical about the structure and the content of the definitive database. Furthermore, verification could be done by means of checking if all data elements are present, sometimes making use of MS Excel to check certain capabilities, being sure that no elements are removed because of restrictions in the length of allowed attributes, etc.

3.3 Preprocessing

Depending on the objective of analysis some preprocessing steps should be carried out. In this section the concepts ‘closed care trajectories’ and ‘multiple resources’ are discussed.

To start with ‘closed care trajectories’ it should be noticed that process analysis often requires a dataset where only ‘finished’ processes are included. For the project of GGzE this means that for those particular analyses, only care trajectories should be used which contain a ‘care trajectory final date’. For the analyses with ProM there was chosen to generate several log files, and as a preparation several databases were constructed. Using this strategy, it was chosen to delete all cases without a final date from the database. In MagnaView however, it is also possible to use a preprocessed dataset, but it appeared that it is quite easy to filter on closed care trajectories. This can be done by means of selecting the tiles tab at the root level of the concerned view and use the filter expression: “not isemptyvalue(Care_trajectory_final_date)”.

Preprocessing with regard to ‘teams’ has been done in order to prevent that one activity is regarded as more than one activity. If for example an activity, such as a consultation, had been performed by more than one professions, say *n* professions, this is registered in the DBC database as *n* activities. Notice that in this example only one consultation took place, and therefore only one consultation for the particular client should be recognized. This in particular leads to wrong calculations when waiting times are concerned. If for example more activities at the same day are registered and these activities are performed by *n* professions, the waiting time *t* from one activity to another is reduced to a mean waiting time which is calculated by *t/n*. Although MagnaView offers some opportunities by means of expressions to filter all abundant activities out, it is chosen to do this filter step for MagnaView, as well for ProM, at the database level. In order to do so, all cases except one are deleted which are of the same care trajectory, took place at the same date, and have the same activity code. The ‘profession’ field of the case left was subsequently modified into “multiple_*name activity level 1*”. The meaning of ‘name activity level 1’ is discussed in section 3.6.

To conclude this section, there should be emphasized that whether it’s needed to preprocess the data depends on the objective of the analysis. In the case where operational measures about client flows (i.e. chain logistics) are concerned, it could be necessary to apply the ‘closed care trajectories’ and ‘teams’ concepts. However, in the case where one wants to state conclusions about resource occupation or utilization (i.e. unit logistics), the mentioned data elements should never be removed.

3.4 Visual analytics

In order to perform visual analytics by means of MagnaView, first two preparation steps need to be executed. These are transformation and loading, which are explained in section 3.4.1 and 3.4.2, respectively. In section 3.4.3 the by MagnaView developed PAS-project and verification of the visualizations will be discussed.

3.4.1 Transformation into MVN-format

MagnaView offers the possibility to use data from various types of data sources, such as ODBC, Access, Excel, text files, etc. Besides, MagnaView gives the possibility to save data obtained from other data sources in a proprietary, native MagnaView data format: mvn. The advantages of using the native file format are the following:

- Data is encrypted, and can only be decrypted by MagnaView. This diminishes possibilities for unauthorized access.
- Data is compressed, and therefore takes less disk space and less time to send to a client. In most cases, MagnaView offers a compression rate which is often better than zip.
- Data is saved in a format which is closely linked to the internal data format of MagnaView, and therefore allows for fast loading. Loading is faster than other treemapping applications. (MagnaView manual, 2009)

When a data source is loaded and saved, the data is converted automatically to the MVN-format. For the GGzE project a single datasheet in MS Access is designed and constructed. This datasheet combines several elements from the GGzE database described in section 3.2.2 and some elements from the code lists described in section 3.2.3. In addition there are specifications concerning activities and professions added to the datasheet. These specifications contain a classification of the activities and professions at different levels, 1 to 3. This is further explained in section 3.6 'filtering and clustering'. The attributes loaded in MagnaView are depicted in appendix F.

3.4.2 Loading data in MagnaView

Before the analyses in MagnaView can be done first another step has to be executed: the attributes of the MS Access database should be linked to the attributes of the MV PAS project. The PAS project developed by MagnaView B.V., is in particular suitable for analysis of care delivery processes. This project contains a number of standard views which are divided over the following categories:

- Organization – Overview
- Process – Overview
- Bottlenecks
- Employees

In order to perform data analysis with MagnaView, first the PAS project is opened, and next the MS Access datasheet is approached by following the path: Tools > Data source > Access. Then the desired datasheet should be selected from a directory. In order to make the PAS project work the main attributes from the MS Access datasheet should be connected to the main attributes of the PAS project, these are depicted in table 2.

Table 2 Main attributes PAS project related to attributes in DBC database

Attribute MV PAS project	*Attibutes Access database*
Class	Care trajectory identification number
Object	Care trajectory identification number
Activity	Activity code
Employee	Procession code
Eventtype	EventType
Timestamp	Timestamp treatment

Further, here the notification has to be made that not all standard views from the PAS project can be used since the timestamp is of a different structure. Therefore some views are removed, and in other cases some expressions are modified. In order to use more information from the DBC database, also some new views are added to the PAS project.

3.4.3 Visualizations MagnaView

3.4.3.1 The PAS project

MagnaView offers the opportunity to visualize all kind of characteristics obtained from a data source. In the previous section there is already mention that for the purpose of the project, MagnaView B.V. offered the dispose of the recently developed PAS project. This project contains a number of standard views which are divided over a number of categories. Although the PAS project seemed ultimately suitable for application within a healthcare setting, some views did not completely fit the DBC-GGZ data. Therefore some modifications had to be carried out. This resulted in a new PAS project called 'PAS-GGZ'. The categories available in the PAS-GGZ project are depicted in figure 10. In appendix H an extensive list of all these categories and their views are shown. Section 4 and appendix L contain an application of the PAS-GGZ project; within these sections the most interesting views are depicted.

1. Analyses
2. Organizational Analysis
3. Overview activities
4. Patterns
5. Dependencies activities
6. Important activities
7. Bottlenecks - Activities
8. Bottlenecks - Activities - Causes high processing times
9. Bottlenecks - Activities - Causes high waiting times
10. Bottlenecks - Employees
11. Bottlenecks - Employees - Causes high processing time
12. Bottlenecks - Employees - Causes high waiting time
13. Bottlenecks - Cases
14. Bottlenecks - Cases - Rework
15. Bottlenecks - Work in Process
16. Employees
17. Specific views

Figure 10 Categories MagnaView PAS-GGZ project

3.4.3.2 Verification of visualizations

Verification of views designed in MagnaView could be done in an explorative way. This means for example that the researcher checks if the calculations correspond with what is expected. Therefore especially exceptional cases can be considered, e.g. clients which face extreme long or short waiting times. Furthermore, also some cases which display mean results should be checked.

3.5 Processes mining

In order to perform process mining by means of ProM, first two preparation steps need to be executed. These are transformation and loading, which are explained in section 3.5.1 and 3.5.2, respectively. In section 3.5.3 the selected ProM analyses and verification of the ProM results will be discussed.

3.5.1 Transformation into ProM MXML format

In order to analyze the data in the MS Access database with ProM, case information, additional case information, information about executed tasks and additional information about executed tasks, that is stored in a MS Access database, should be converted to the ProM MXML file format (Mans, ?). The MXML file, on its turn, can be read by the ProM tool. For converting the data to the MXML format, four tables with a similar structure as that of fields in the MXML format have been defined. The MXML format is depicted in appendix E. For now there is assumed that the reader is familiar with the idea behind Process Mining and the MXML format. More information about Process Mining and the MXML format can be found in van Dongen et al. (2005). The elements in the MXML format that can contain information about cases and tasks that have been executed are respectively the *Process Instance* element and the *Audit Trail Entry* element (figure 11, second row). Furthermore, both the Process Instance element and the Audit Trail Entry element can have data as sub element which can contain additional information about process instances and audit trail entries respectively. Additional information can be stored in the tables *Data_Attributes_Audit_Trail_Entries* and *Data_Attributes_Process_Instances*. The entity relation diagram for the four process tables is depicted in appendix E, an extensive description of the four elements and their attributes can be found in Mans (?).

Before the process mining tables can be generated and filled, first tables with GGzE data should be defined and constructed in the MSAccessPlugin. For this step Mans' "example database runningExampleMsAccessPlugin.mdb" has been used. For the GGzE project there were three tables defined, which are 'Admission', CareType', and 'Treatments' (figure 11). The first two tables contain information about the process instances, i.e. care trajectories, and the third table contains information about the audit trail entries, i.e. activities.

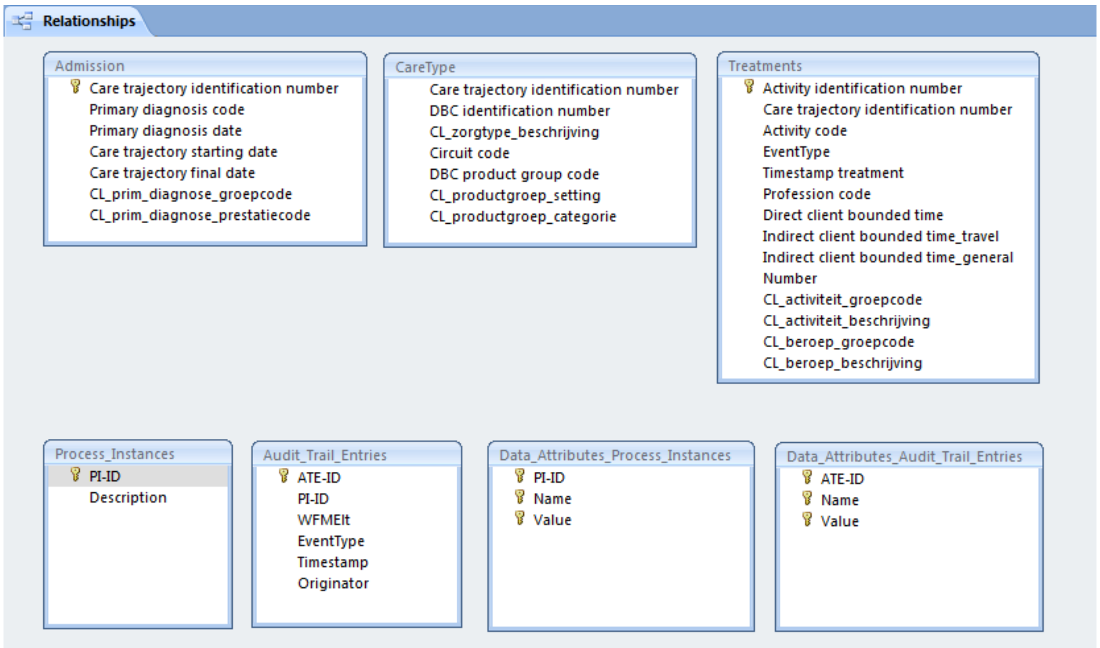


Figure 11 Relationship diagram MSAccessPlugin for ProM

The next step is to fill the four process mining tables by means of running the functions in the Visual Basic script. Therefore, first some modifications of the functions in the batch method in the script from the runningExampleMsAccessPlugin.mdb should be made. The sub batch used for the GGzE plug-in is depicted in figure 12. When executing this method, the information stored in the 'Admission', 'CareType', and 'Treatments' tables are added to the 'Process_Instances', 'Audit_Trail_Entries', 'Data_Attributes_Process_Instances', and 'Data_Attributes_Audit_Trail_Entries' tables.

```
Sub batch()

  'Fill PI tables
   colNames = returnFieldNamesInArray("Admission", 1, -1)
   addPIandAttr "Process_Instances", "Data_Attributes_Process_Instances", "Admission", "Care trajectory identification
number", "Primary diagnosis code", colNames, ""

   'Add CareType to the data attributes table for the process instances
   colNames = returnFieldNamesInArray("CareType", 1, -1)
   addDataAttributes "CareType", "Care trajectory identification number", "", "Data_Attributes_Process_Instances", colNames

   'Add treatments which have its own id
   colNames = returnFieldNamesInArray("Treatments", 1, -1)
   addATEandAttr "Audit_Trail_Entries", "Data_Attributes_Audit_Trail_Entries", "Treatments", "Activity identification number",
"Care trajectory identification number", "Activity code", "EventType", "Timestamp treatment", "Profession code", colNames, ""

End Sub
```

Figure 12 Batch method in Visual Basic script

The last thing which needs to be done is converting the data in the four tables to the ProM MXML format. To this end, the ProM Import framework can be used. First, an ODBC connection for the ProM Access database should be set up. When this is done, the filter properties tab of the MS Access database plugin which is part of the ProM Import tool should be filled in. The result of the conversion is a MXML log file.

3.5.2 Loading data in ProM

In ProM the log file can be approached by following the path: File > Open MXML log file. Than the desired log file should be selected from a directory. Automatically the dashboard depicted in figure 13 appears. On one glance, it tells the total number of processes, cases and events that are contained in the log. Furthermore, the number of event classes, that is, different kind of log events, and event types, such as 'start' and 'complete', and originators are shown (see "Key data" in figure 13). In the middle a graphical representation of the total number of events per case, and of the number of different events per case is shown. The cases are simply sorted along the x-axis based on their amount of events, or their amount of different events, respectively. This can give very useful profile information about the diversity of the log! For example, it is easy to spot if there are many short and only a few very long process instances. Finally, to the "Log info" section contains meta information and the spanned time frame of the log. The button below directly brings up the action trigger, which enables mining or further analysis of the log (www.processmining.org).

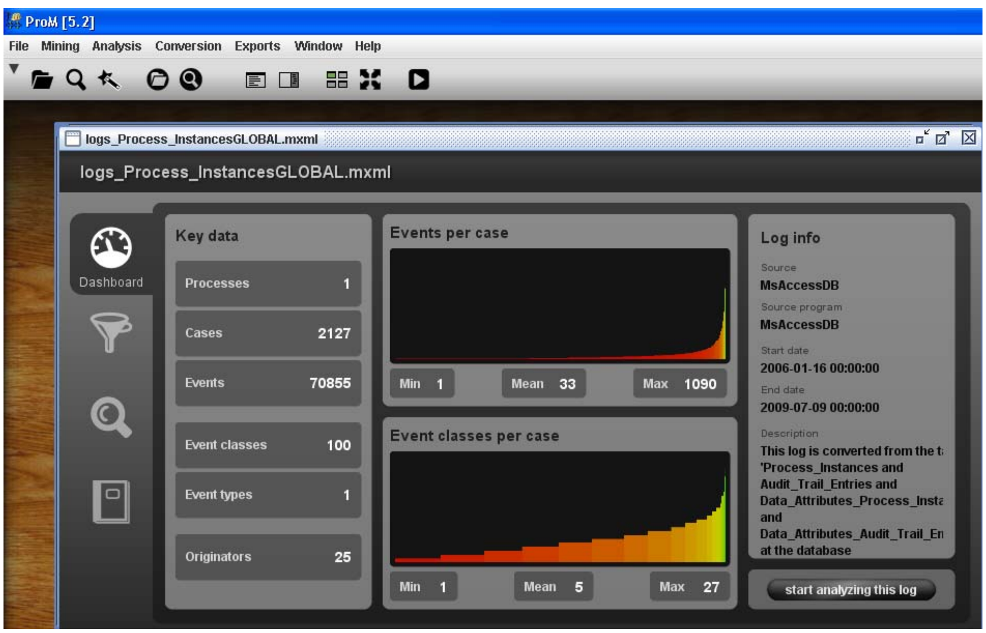


Figure 13 Screenprint of ProM dashboard appearing when opening a log file

3.5.3 ProM analyses

For the analyses of care delivery processes in GGzE Centre child and adolescent psychiatry with ProM, a selection of mining plug-ins and analysis-plugins is made in order to discover the processes. The selected mining plug-ins are: heuristic miner and fuzzy miner. The selected analysis plug-ins are: performance sequence diagram, dotted chart analysis, originator by task matrix, and log summary. The selection is based on other case studies applying ProM and the capabilities with regard to complexity of the mental healthcare processes. The plug-ins are described below.

3.5.3.1 Mining plug-ins

The heuristic miner and fuzzy miner both focus on the discovery of the control flow. These process models reflect the causal dependencies of activities observed in an event log. With control flow mining, process models are automatically derived from event logs. The generated process model reflects the actual process as observed through real process executions. According to Mans et al. (2008) process models of healthcare process logs give insight into care paths of patients. Usually, processes in the healthcare domain do not have a single flow but a lot of variants based on patients and diseases. As a consequence, the derived models look spaghetti-like and are too complex to understand easily. This problem arises when the heuristic miner is approached on “all” data in GGzE Centre child and adolescent psychiatry. Although, in process mining terms, the heuristic approach is relatively robust (i.e., it can deal with noise and incompleteness) and has options to focus on the main process instead of trying to model the full details of the behavior reported in the log (van der Aalst et al., 2007b), this model approach typically results in a low fit on healthcare processes. Therefore, Mans et al. (2008) argues that approaches for dealing with unstructured processes are for example clustering or abstraction, or a combination of those.

One approach for dealing with unstructured processes is the Fuzzy Miner (Mans et al., 2008). The Fuzz Miner addresses the issue of mining unstructured processes by using a mixture of abstraction and clustering techniques and attempt to make a representation of the (unstructured) process that is understandable for analysts. The miner provides a high-level view on the process by abstraction from undesired details, limiting the amount of information by aggregation of interesting details and emphasizing the most important details. The Fuzzy Miner provides an interface where these settings can be easily configured and the resulting model can directly be observed. In addition, the Fuzzy Miner offers a dynamic view of the process by replaying the log in the model. Furthermore, the Fuzzy Miner includes the option of executing an animation, which shows cases flowing through the model. In the animation, frequently taken paths are highlighted, which prevent them from being overlooked.

3.5.3.2 Analysis plug-ins

The first analysis plug-in mentioned is the performance sequence diagram. The purpose of the performance sequence diagram plug-in is to provide the user with a means to assess the performance of processes. This plug-in provides information about what behavior in the processes is common, what behavior is rare and what behavior may result in extreme situations (e.g. instances with extremely high throughput times). Furthermore, the performance sequence diagram plug-in allows to focus on a certain data-element (such as taskID, originator, department) and see how transfer of work between instances of the selected data-element takes place for each case. In the pattern diagram of the performance sequence diagram, the patterns are displayed, sorted based on the frequency of sequences that follow the pattern (the pattern with the highest frequency if displayed at the top). Furthermore, information such as the mean throughput time of the patterns is available, which can determine the patterns that seem to be common behavior, those that are rare and those that result in high throughput times (www.processmining.org).

The second analysis plug-in discussed here, which is the most import plug-in for the GGzE project, and available in ProM as well as in MagnaView, is the dotted chart. The dotted chart is a chart similar to a Gannt chart. It shows a spread of events of an event log over time. The basic idea of the dotted chart is to plot dots according to the time. Since the dotted chart diagram was of particular interest for the GGzE project, an example view is depicted in figure 14. In the chart, a dot on the chart represents a single event in the log, The chart has two orthogonal dimensions: (1) time and (2) component types. The time is measured along the horizontal axis of the chart. Along the vertical axis, component types such as instance, originator, task, event type, or data elements are shown. In the case of figure 14, the care trajectories (or instances) are shown along the vertical as. Furthermore, the relative time option has been used and components are sorted by duration.

The dotted chart in ProM provides the metrics related to events and their distribution over time (spread). There are two kinds of performance metrics: (1) metrics for the overall event log and (2) metrics for each component. For the overall event log, (a) the position of the first event in the log, (b) the position of the last event in the log, (c) average spread, (d) minimum spread, and (e) maximum spread can be calculated. For each component type, (1) the position of the first event in a component, (2) the position of the last event in a component, (3) average interval between events, (4) minimum interval between events, and (5) maximum interval between events can be calculated (www.processmining.org).

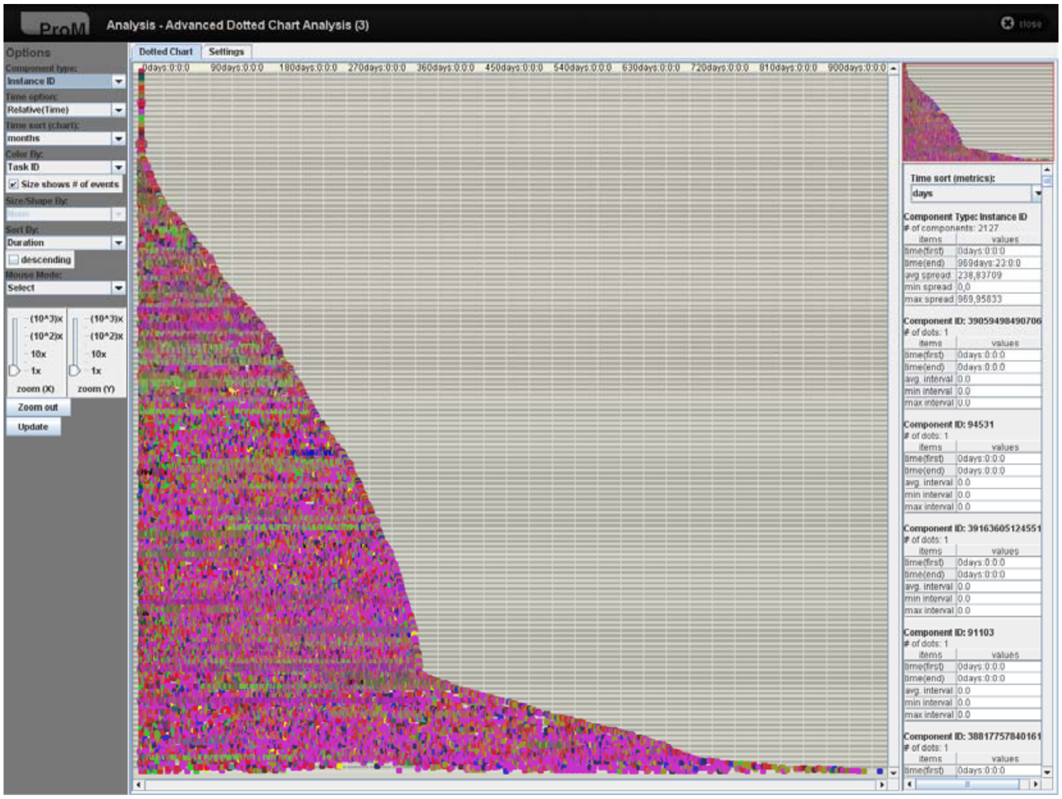


Figure 14 Dotted chart analysis ProM applied at GGzE Centre child and adolescent psychiatry

Furthermore the originator by task matrix, showing how frequently each originator conducts specific activities, is of interest for the GGzE project, especially when aiming at an application of the focused factory concept (section 2.3.3). Also this analysis can be conducted by ProM and by MagnaView. And the last but certainly not the least analysis plug-in, the Log summary, which is used several times during the GGzE project. The "Log Summary" provides an overview about meta data and simple frequency statistics for a log, such as the number of process instances, log events and originator actions. It can be exported as an HTML document (www.processmining.org).

3.5.3.3 Verification of ProM results

In order to verify if the analyses in ProM give a good representation of reality, the mined models (mining plug-in) should be evaluated on model fit. For analysis done by means of the analysis plug-in no obvious verification tools are available. However, of course the researcher should always check if the log file contains the data which he/she expects that the log file contains, e.g. number of care trajectories, number of activities, types of originators, etc.

3.6 Filtering and clustering

Since the care delivery process at GGzE Centre child and adolescent psychiatry are very complex by nature, filtering and clustering techniques are needed in order to state conclusions about the processes and approach them more convenient. Ultimately, filtering and clustering techniques can be used to distinguish patient groups fulfilling the criteria (homogeneous in terms of process and market performance) (section 2.3.2). Although, ProM also offers possibilities to filter and cluster data elements, it is chosen to perform all filtering and clustering activities on database level or in MagnaView. Thereafter, filtered data can be exported to a .txt file and subsequently, with some steps in between, be imported in ProM. However, notice that some of the analyses in ProM perform clustering by means of mining algorithms, these are not meant here, and are already discussed in section 3.5.3. Below some manual filtering and clustering approaches applied on DBC-GGZ data concerning GGzE Centre child and adolescent psychiatry are described.

(dis)Aggregation of activities and employees
The first clustering and filtering approach concerns aggregation (or when used reversely, disaggregation) of activity and employee coding and naming. The 'activity codes' and 'profession codes' as depicted in 'Figure 9 MS Access DBC-database architecture' are specified for three levels each, based on the professions list (beroepentabel) and activities and operations list (activiteiten en verrichtingen table) included in Spelregels DBC-registratie (2009). For all three levels there are two attributes defined, one contains the 'name' of the employee group or activity (group) and the other contains a 'coding' representing an employee group or activity (group). An example of the filters used in MagnaView is depicted in figure 15. Notice, that these filters also can be used for clustering purposes by simply selecting/deselecting the checklist boxes. Moreover, the researcher can chose to use more aggregated/disaggregated coding/naming when connecting the attributes from the database to the PAS project as depicted in table 2.

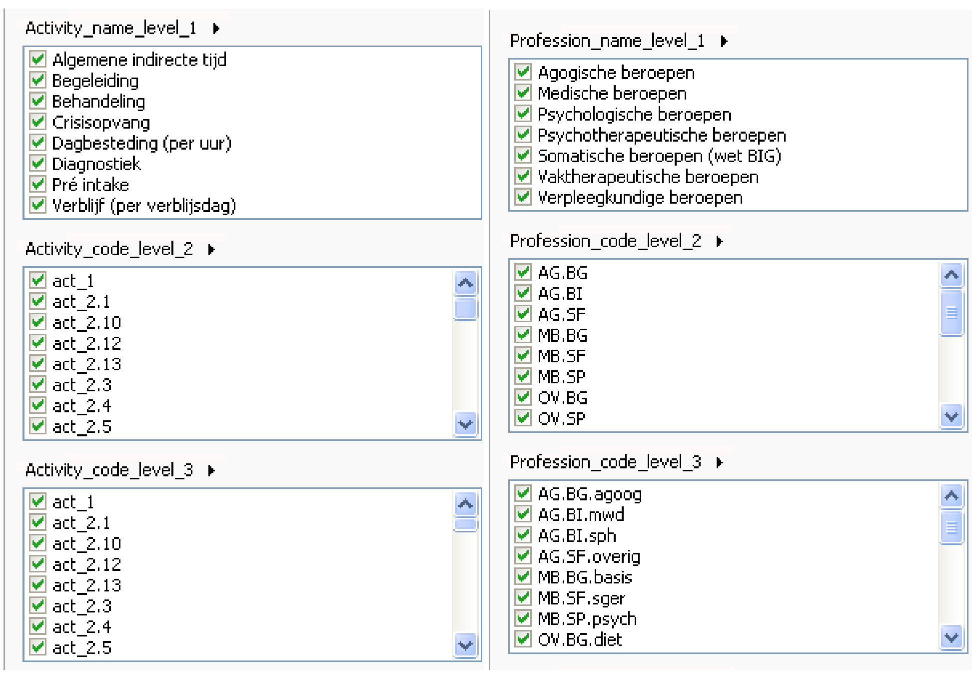


Figure 15 Example MagnaView filters Activity and Profession aggregation

Care trajectory characteristics
Clustering and filtering options can also be approached on care trajectory level. Here it makes sense to first give a formal definition of a care trajectory in the context of the DBC systematic: 'A care trajectory is a succession of one initial DBC with one or more proceeding DBCs with the same primary diagnoses. A care trajectory describes the entirety of activities and operations which for one specific primary diagnoses is delivered to a patient (across the DBCs)' (DBC-begrippenlijst voor GGZ, 2008). For the project at GGzE Centre child and adolescent psychiatry four attributes are selected for filtering and clustering options these are: primary diagnose performance, care type element, product group setting, and circuit description. An example of the care trajectory filters used in MagnaView is depicted in figure 16. Note, that all filters are based on the attributes from code lists

and not any originates from the initial DBC database as depicted in figure 9. Moreover, code list attributes are connected to the tables ‘Care trajectory’ and ‘DBC trajectory’.

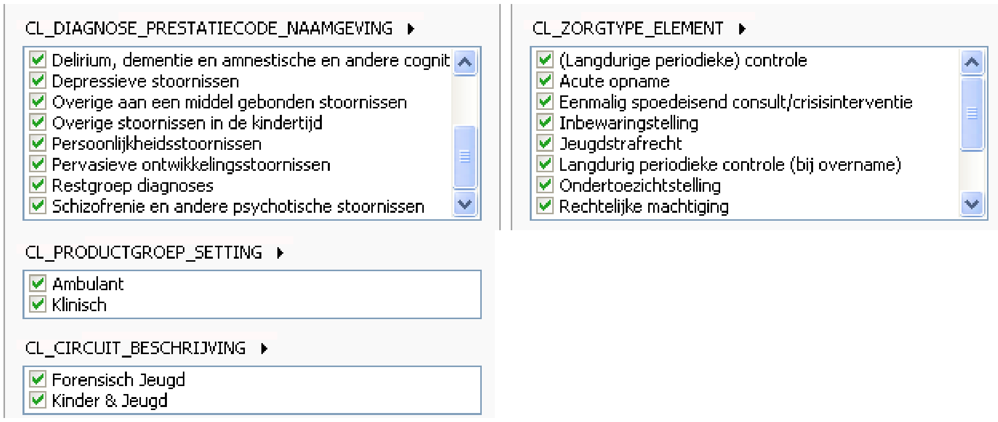


Figure 16 Example MagnaView filters care trajectory characteristics

Client characteristics

Although most client information is anonymous, some client characteristics are included in the database which are for example age and sex. The applied filter options for these attributes are depicted in figure 17. In line with classification often used within GGzE Centre child and adolescent psychiatry (section 2.1.2), the age filter is adjusted to checklist boxes with the two options younger than 12 years and 12 years old and older. In MagnaView the following expression has been used: ‘(age(ZA_date_of_birth; Care_trajectory_starting_date)) < 12’. The checkbox for age can be explained as follows: 1 is male, and 2 is female.

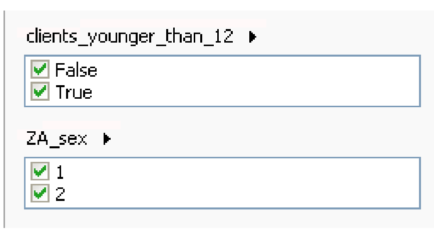


Figure 17 Example MagnaView filters client characteristics

Chain logistics characteristics

During the project also some less obvious filtering and clustering applications are developed. These concern clustering on waiting times between two successive activities and the number of activities in a care trajectory.

Figure 18 Example MagnaView filter waiting time

For clustering on waiting times the checkboxes in figure 18 is used. By means of this checkboxes the user can select if he/she wants to approach the concerning view with or without care trajectories with a long waiting time. In order to define waiting time the following expression in MagnaView is used: ‘count(filter(children;int(categoryname)>90 and int(categoryname) <> 99999)) > 0’. In this expression the waiting time of two successive activities is set at more than 90 days. Meaning that if one selects the ‘True’-checkbox, all care trajectories where at least one succession of two activities last at least 90 days are kept in the visualization. The user can replace the number of waiting days by its own preference. For example one can choose to analyze those care trajectories for waiting times longer/shorter than 30 days, than ‘>90’ should be replaced by ‘>30’.

Filtering on the number of activities of a care trajectory is for the project only applied on the 'dotted chart' view of MagnaView, more information about the dotted chart view is given in section 3.5.3. Figure 19 gives an indication about how filtering on the number of activities can be done. In the dotted chart view at the 'object_id' level (which is the care trajectory level) a filter for a visibility expression can be activated. The expression belonging to this filter is 'tilescount >5', which means that only care trajectories containing more than 5 activities should be kept in the visualization. Again, the user can replace the number of activities by its own preference. For example one can choose to analyze those care trajectories which have 5 or less than five activities, than '>5' should be replaced by '<6'.

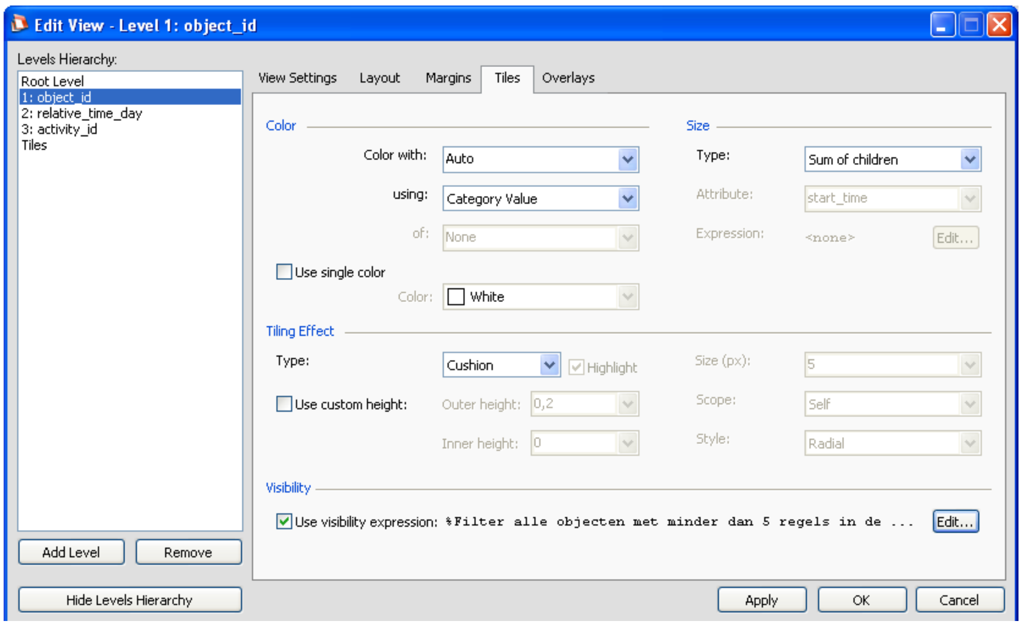


Figure 19 Tiles tab dotted chart view at root level 1

To close this section, it can be concluded that many manual clustering and filtering options are available and easy to apply. A user can filter on all data elements depicted in 'Figure 9 MS Access DBC-database architecture', on all combinations offered by the code lists attributes, as well as on all other (logistical) expressions defined by the user itself. Although this offers many opportunities for visualization of all kind of process aspects, formulation of proper performance indicators, and in particular process indicators, emerges.

3.7 Validation

Validation of the results gained by application of the method should be done by involvement of stakeholders. Therefore a number of presentations, followed by discussions, have been organized. The content and audience of these presentations are discussed in the next chapter, section 4.4. Furthermore, close cooperation with GGzE project manager care logistics management ascertains for a major part the validation of case results.

4 Case results GGzE Centre child and adolescent psychiatry

In this section the method described in chapter 3 has been applied by means of a case study at GGzE Centre child and adolescent psychiatry. The characteristics of the DBC-GGZ dataset, on which the application is based, are described in section 1. In the second section the process analyses will be discussed. Within this section, first the application of the MagnaView PAS-GGZ project is explained. Secondly, the application of selected ProM plug-ins on the GGzE data is represented. Then, in the third section a model for identifying client groups of GGzE Centre child and adolescent psychiatry is developed and verified. Then in section 5 the validation of the case results is considered. Finally, in section 6, an evaluation of the method is included.

4.1 Dataset specifications

The data analyses part of the project is based on DIS DBC data recorded at GGzE Centre child and adolescent psychiatry. The considered data are delivered to DIS from November 2007 till November 2009. In total the dataset existed of 21 zip files, each containing separate .txt files concerning client, care trajectory, DBC trajectory, diagnoses, activities, day spending activities, and days of stay. A description of de DBC data files and the designed database can be found in section 3.2.1 and 3.2.2, respectively. Moreover, there are additional data specifications coupled to the designed database, originating from the GGZ code lists (section 3.2.3).

The first starting date of a care trajectory in the database is October 31, 2005. And the last final date of a care trajectory in the database is December 29, 2009. In total the dataset counts 3511 identical clients. For these clients 3607 identical care trajectories are opened. The database contains 2127 closed care trajectories, meaning that for these care trajectories a starting date and a final date is defined.

4.2 Process analyses

Within this section a number of analyses by means of MagnaView and ProM are discussed. Where sections 3.4 and 3.5 gave an overview of the possibilities, here the applications are discussed.

4.2.1 Magnaview analyses

The applications of the MagnaView PAS-GGZ project discussed in this section are part of the method and validated by means of presentations and discussions with managers and professions of GGzE Centre child and adolescent psychiatry (K&J), managers and researchers of GGzE Centre research and development (O&O), and specialists of MagnaView B.V. The validation-step is discussed in section 4.4. Within this section a description of the views included in the presentations, designed by means of the MagnaView tool, are discussed. Appendix L contains the presentation: Cliëntstromen in GGzE Centrum Kinderen en Jeugdpsychiatry (client flows in GGzE Centre child and adolescent psychiatry). The analyses are divided over three categories: process characteristics, bottlenecks, and process patterns. These are discussed in this order below.

4.2.1.1 Process characteristics

Process characteristics related views presented in the presentation 'Cliëntstromen in GGzE Centrum Kinderen en Jeugdpsychiatry' (appendix L) are: arriving pattern of clients (sheet 5), throughput times of clients (sheet 6), number of care trajectories per primary diagnosis (sheet 11), activities and their originators (sheet 12), number of activities per primary diagnosis (sheet 13), and first and last activities or care trajectories (sheet 14). These views are described below.

Arriving pattern of clients

The arriving pattern of clients is depicted in sheet 5. The view shows the frequency of clients arriving at GGzE Centre child and adolescent psychiatry pro week over the years 2007 and 2008. Since we had to deal with some warm up and cooling down effects in the data, 2006 and 2009 are not included in this analysis. Typically, the graph shows variation in the arriving patterns, meaning that the frequency of arriving clients differs over time. During discussions with experts several causes of this variation came up, for example, there is expected that arrival peaks occur after school holidays. A nice feature of the view is that when one filters on for example primary diagnoses and as a result the magnitude of the arriving instances changes, the scale of the Y-axis is automatically adjusted in order to get maximum understanding of the displayed results.

Throughput times of clients

A second overall process measure, throughput times of clients, has been shown in sheet 6. In this analysis only closed care trajectories, i.e. containing a starting and final date, are concerned. The care trajectories, ordered at ascending throughput times, are depicted on the X-axis. The Y-axis depicts the throughput times in days. From this graph we can conclude that the mean throughput time of a closed care trajectory is about 280 days. Remarkable about this graph is that the majority of care trajectories lasts less than 100 days, and only a few lasts a couple of years (up to 960 days). Furthermore, two bending curves can be distinguished; one at 365 days and one at 730 days. It is expected that the cause of this pattern is related to the maximum duration of a DBC which is 1 year. During discussions with experts it has been concluded that these shapes are due to administration causes, i.e. care trajectories are often closed when it is compulsory by the DBC systematic, and not when the actual care delivery process has been finished.

Number of care trajectories per primary diagnosis

For the third analysis clustering on data is approached. Sheet 11 depicts the number of care trajectories per primary diagnosis. On the Y-axis the number of care trajectories per primary diagnosis group is depicted. The X-axis depicts the primary diagnoses, ordered at ascending number of care trajectories in this group. The primary diagnoses naming are based on the data-element "CL_diagnose_prestatiecode_naamgeving" originating from the code lists 2009. From the view can be concluded that 1594 of in total 3607 care trajectories are characterized as care trajectories of which the clients are diagnosed with a 'pervasieve ontwikkelingsstoornis' (autisme). This is about 44%. The second largest group, is diagnosed with 'aandachtstekortstoornissen en gedragsstoornissen' (ADHD), and covers 23% of all care trajectories within GGzE Centre child and adolescent psychiatry. Other categories are: 'aan alcohol gebonden stoornis'; 'aanpassingsstoornissen'; 'andere aandoeningen en problemen die een reden voor zorg kunnen zijn', 'angststoornissen', 'bipolaire en overige stemmingsstoornissen', 'delirium, dementie en amnestische en andere cognitieve stoornissen', 'depressieve stoornissen', 'overige aan een middel gebonden stoornissen', 'overige stoornissen in de kindertijd', 'persoonlijkheidsstoornissen', 'restgroep diagnoses', and 'schizofrenie en andere psychotische stoornissen'. Although auditors reacted positively on the presented view, it is recommended to take into consideration whether these groups lead to sufficient accurate results for classifying care trajectories with regard to defining iso-process client groups. Furthermore it is worth to mention here, that besides a classification of diagnoses, this view also allows for filtering on clinical and ambulant settings.

Activities and their originators

Sheet 12 depicts the latent skills of employee groups. This view typically shows which activities are performed by which originator. On the Y-axis the activities are depicted. These are shown on a 'level 2 name level', which is described in section 3.6. The originators at a level 3 naming level are depicted on the X-axis. The colored boxes indicate that an activity is performed one or more times by the concerning employee group. The latent skills view is comparable with ProM's originator by task matrix analyses, showing how frequently each originator conducts specific activities (section 3.5.3). Addition of frequencies is eventually also possible in MagnaView.

Number of activities per primary diagnosis
In order to compare the type of activities of each primary diagnosis, the ‘activity occurrence per primary diagnosis’ view is designed (sheet 13). In this view all primary diagnosis are shown on an equal scale. The number of activities occurred for the particular primary diagnosis is however depicted in the upper right corner. Within each primary diagnosis square the relative number of activities is shown together with the percentages the activities account for. As an example we can conclude that 41 percent of the activities of the primary diagnosis ‘pervasieve ontwikkelingsstoornis’ are of the type ‘behandeling’. The second largest category of this diagnosis is ‘algemene indirect tijd’ which accounts for 36 percent. Furthermore, about one-fifth of the time is devoted to the activity groups ‘verblijf’, ‘diagnostiek’, and ‘dagbesteding, these groups account for 11%, 9%, and 2% respectively of the total activities. Only a small number of activities of the primary diagnosis ‘pervasieve ontwikkelingsstoornis’ are of the type ‘pre intake’, ‘begeleiding’, and ‘crisisopvang’. Note that for the view on sheet 13, the activities are shown at a level 1 naming level; of course the user can chose here to apply the level he/she likes. Also there are zooming possibilities, e.g. by simply filtering on primary diagnosis, only the primary diagnoses of interest are shown on the screen. Furthermore, by clicking on the smallest component of the view, a tile, MagnaView automatically shows the ‘case specific view’, in which detailed characteristics of the ‘care trajectory’, of which the activity is part, are shown.

First and last activities of care trajectories
The last views depicting process characteristics are shown on sheet 14. Here the first activities of a care trajectory are shown on the left, and the last activities of a care trajectory are shown on the right. It is in particular notable that most care trajectories start (40 %) and end (49 %) with an activity of category ‘7’, which means ‘algemene indirect tijd’ and can be devoted to consultation between experts. Furthermore, it is remarkable that a first activity of a care trajectory is more often of the type ‘behandeling’ than of the type ‘pré intake’ or ‘diagnostiek’. Of course for this view holds again that the user can zoom in on the activity types by simply choosing a different level of naming or coding. Furthermore, it makes sense to add the comment here, that more sequence related views are available in MagnaView. Although not included in the presentation, the views in which dependencies between activities, that is ‘next’ and ‘previous’ activities of a particular activity are depicted, are in particular of relevance when one wants to gain more knowledge about the routing of care trajectories.

4.2.1.2 Bottlenecks

For presentation purposes there is chosen to include only two ‘bottleneck’ views in the presentation ‘Cliëntstromen in GGzE Centrum Kinderen en Jeugdpsychiatry’ (appendix L). These are ‘waiting times per activity’ (sheet 15) and ‘waiting times per employee’ (sheet 16), which are explained below.

Waiting times per activity
The first bottleneck view is ‘waiting times per activity’ and is depicted on sheet 15. In this view the waiting times in days are depicted on the Y-axis. And on the X-axis the activities, on a level 2 coding scale, are set out. Important to denote is that the waiting times in the MagnaView project are calculated by the difference in time between two consecutive activities of the DBC GGzE dataset. Thus, by means of this data analysis technique, it is not possible to draw conclusions about waiting times based on the difference ‘date of request for an activity’ and ‘date of execution of that activity’. This example shows again that it is of major interest to precisely formulate the criteria for waiting times and waiting lists measures. Respecting the measure type in sheet 15, there can be conclude that clients wait longest for diagnostic activities and ‘pré intake’. In particular, the mean waiting time for activity 2.7, which is ‘orthodidatisch onderzoek’, is with 70 days the highest of all activities. However, note that the bottlenecks views do not take the frequency of activity occurrence (or employee devotion) into account. In order to get a better understanding which activities contribute

most to the overall waiting times, the researcher could apply some additional performance indicators. An example mentioned during the evaluation with MagnaView experts is to calculate the product of activity occurrence and the mean waiting times of that particular activity.

Waiting times per employee
The mean waiting times per employee are depicted on sheet 16. Like the 'waiting time per activity'-view, also this view shows the waiting times in days on the Y-axis. The employee groups on a level 3 scale are represented on the X-axis. From this graph can be concluded that the mean waiting time for a paediatrician is the highest from all employee groups, this amounts 45 days. The second highest bar in the graph depicts a conversion error, which is cause by activities not performed by an employee, i.e. 'verblijf' and 'dagbesteding'. The waiting time a client faces for a 'pré intake' by multiple employees takes on average 32 days. Although left out of consideration in this report, it is recommended to take a closer look at variation of waiting times.

4.2.1.3 Process patterns

The last two views designed by means of the MagnaView PAS-GGZ project and presented and discussed during presentations named 'Cliëntstromen in GGzE Centrum Kinderen en Jeugdpsychiatry' (appendix L), are: number of activities per care trajectory (sheets 17 till 19), and relative duration of care trajectories (sheets 20 till 26). These views are described below.

Number of activities per care trajectory
The view 'number of activities per care trajectory' (sheet 17) visualizes process patterns sequentially. Along the Y-axis the care trajectories arranged by number of activities in ascending order are set out. Obviously, the sequence of activities of the care trajectories are shown horizontally. Note that this view does not show any waiting times between the activities. As a result the shape of the curve is characterized by a negative exponential distribution, i.e. concave shaped. This indicates that relative many care delivery processes in GGzE Centre child and adolescent psychiatry contain only a few activities, and that for only a few client flows lots of activities have been registered. In order to get more insights about the characteristics of client flows, filtering on primary diagnosis has been applied. Sheets 18 and 19 depict the number of activities per care trajectory filtered on the primary diagnosis 'aandachtstekortstoornissen en gedragsstoornissen' (ADHD) and 'pervasieve ontwikkelingsstoornis' (autisme), respectively. Although some deviation can be identified in the 'aandachtstekortstoornissen en gedragsstoornissen' curve, there can be concluded that both curves, of these largest diagnosed client groups, are negative exponential distributed with more less the same parameters. This brings us to the point that analysis of care trajectory including waiting times should be performed. This has been done by means of the view 'relative duration of care trajectories', which is discussed next.

Relative duration of care trajectories
Sheet 20 depicts all closed care trajectories of GGzE Centre child and adolescent psychiatry arranged by relative duration. Along the Y-axis the care trajectories ordered at ascending relative duration are set out. And similar to the 'number of activities per care trajectory'-view, the sequences of activities of the care trajectories are shown horizontally. In contrast to the previous view, the 'relative duration on care trajectories' view does show the waiting times between the activities. As a result the shape of the curve is characterized by a belly distribution, i.e. spherical shaped. Based on this view additional analysis has been done in order to identify client groups, this analysis is described in section 4.3. In order to perform additional analysis, first distinct client groups, based on throughput times of care trajectories and the number of activities performed, have been hypothesized during a brainstorm session with GGzE project manager care logistics management. The resulting diagram in which these hypothesized client groups are depicted is shown on sheet 21. In order to perform additional analysis, again the filtering capability of MagnaView is used to select care trajectories with certain characteristics. In particular the following filters are used: care trajectories containing more/less than 5 activities, longer/shorter waiting time (in days) between two successive activities, and primary diagnosis.

The first filter used is based on distinguishing care trajectories with more/less or equal than 5 activities. In particular the number 5 is chosen because route 1, i.e. the first operational phase of GGzE Centre child and adolescent psychiatry (Linkens, 2009; section 2.1.2), consists of 5 activities which are: application, screening, intake, assessment, and PCP (Program Coordination Point). From Linkens' process description it is assumed that at least five activities should have been performed in order to regard the client being part of the target group of GGzE Centre child and adolescent psychiatry. Filtering all care trajectories with 5 or less than 5 activities out resulted in the graph shown on sheet 22. In comparison with the graph where all care trajectories are taken into account, the tail at the top of the graph disappeared. Furthermore, the graph in sheet 22 is somewhat more spherical shaped.

The second filter applied on the 'relative duration of care trajectories' visualization is based on distinguishing care trajectories with longer/shorter waiting time (in days) between two successive activities. Although in section 4.3 has been chosen for a distinction with cutoff points of 30, 60, and 90 days, the presentation in appendix L only applies the distinction of less/more than 60 days waiting times. Long time no treatment for more than 90 days would however be a good measure, since the appointment has been made within GGzE Centre child and adolescent psychiatry that clients who do not face treatment for 3 months should be deregistered and eventually later on registered with a new care trajectory ID. The measures 30 and 60 days are chosen intuitively, in order to get a better understanding about the efficiency and the composition of the processes with these characteristics. Sheets 23 and 24 depict the relative duration of care trajectories with more than 5 activities filtered on the 'waiting times less than 60 days between two successive activities' and 'waiting times more or equal than 60 days between two successive activities', respectively. To conclude: when waiting times between two successive activities in a care trajectory are larger, the graph is more spherical shaped.

The last filer applied on the 'relative duration of care trajectories' graph is concerning primary diagnosis. For presentation reasons sheets 25 and 26 just depict the graphs of sheets 23 and 24, but then filtered on care trajectories which are characterized by the primary diagnosis 'pervasieve ontwikkelingsstoornis' (autisme). Although there are relative less care trajectories included in the graphs 25 and 26, there can be no large differences distinguished from the graph on sheets 23 and 24.

A more extensive analysis for the identification of client groups by means of filtering techniques in the 'relative duration of care trajectories' visualization is included in section 4.3. Furthermore, the hypothesis of distinct client groups based on throughput times of care trajectories and the number of activities performed will be validated.

4.2.2 ProM analyses

Although the presentation 'client flows in GGzE Centre child and adolescent psychiatry' (appendix L) only includes a heuristic mined view as a result of applying the ProM framework, it appeared that by applying clustering and filtering techniques (section 3.6) more conveniently arranged process visualizations can be generated. In this paragraph first the selected process mining approaches will be discussed. Secondly, the process analysis plug-ins have been described. A description of the selected plug-ins is given in section 3.5.3.

4.2.2.1 Process mining

In this section the selected process mining approaches 'heuristic miner' and 'fuzzy miner' will be discussed.

Heuristic miner
Sheet 8 in appendix L depicts a process model of all closed care trajectories in GGzE Centre child and adolescent psychiatry. This process model obtained by means of the heuristic miner plug-in is

typically characterized by complexity and inconvenient arrangement, i.e. a spaghetti model. The small part zoomed in depicted on sheet 9, emphasizes once again how many in- and outgoing arcs can be identified at the lowest aggregation level. This example typically shows the need for filtering and clustering techniques. In order to achieve more convenient arranged process models the activities can for example being aggregated to a higher level. Appendix I figure 32 shows the application of aggregation of the activities on a level 1 naming level. This heuristic net depicts the set of tasks: 'Diagnostiek', 'Pré-intake', 'Behandeling', 'Verblijf', 'Begeleiding', 'Crisisopvang', 'Algemene indirect tijd', and 'Dagbesteding'. The arcs between the tasks denote the inferred ordering relations based on their frequencies, i.e., the dependency measure indicates how certain we are that there is a dependency relation between two activities A and B. A high value (close to 1) means that we can be very sure that there is a dependency relation between the connected tasks (Weijters et al., 2006). Although the heuristic net with level 1 naming level results in a satisfactory orderly model, there is still a major problem when fitness is concerned. The fitness measure assesses the quality of individuals by replaying the log traces into these individuals; a fitness of 1.0 indicates a perfect fit. Applying default settings, it has been calculated that the measures ProperCompletion, and StopSemantics have a fitness of 0.0. Other fitness measures gave the following results: ContinuousSemantics 0.359, ImprovedContinuosSemantics 0.583, and ExtraBehaviourPunishment 0.559.

Fuzzy miner

Since, traditional mining approaches, for example heuristic mining, have problems dealing with unstructured processes. The discovered models are often 'spaghetti-like'; showing all details without distinguishing what is important and what is not. Therefore, Günther and van der Aalst (2007) propose a process mining approach, which is fuzzy mining. This approach is configurable and allows for different faithfully simplified views of a process. To do this, the concept of a roadmap is used as a metaphor to visualize the resulting models. Based on an analysis of the log, the importance of activities and relations among activities are taken into account. Activities and their relations can be clustered or removed depending on their role in the process. Moreover, certain aspects can be emphasized graphically just like a roadmap emphasizes highways and large cities over dirt roads and small towns.

As an example appendix I figure 33 depicts a fuzzy model based on DBC data GGzE Centre Child and adolescent psychiatry. Prior to mining the log, filtering in the data set has been approached. The remaining care trajectories are characterized by a pervasive diagnosis, contain more than 5 activities, and have no waiting times longer than 60 days. In addition the activities (and originators) are aggregated to a level 2 coding scale. The model is mined applying the default parameter settings in the fuzzy miner plug-in.

The graph notation used is fairly straightforward. Yellow square nodes represent event classes, their significance (maximal value is 1.0) is provided below the event class name in each node. The fuzzy model in figure 33 depicts the event classes: act_3.1, act_7.1, act_7.3, act_7.4, act_7.5, act_8.5, and act_9.4. From appendix G can be found that these concern the activities: 'communicatieve behandeling', 'zorgcoördinatie', 'interne patiëntbespreking (MDO), 'extern overleg met derden (buiten de instelling)', 'verslaglegging algemeen (b.v. ontslagbrief, correspondentie)', 'verblijf forensisch', and 'dagbesteding arbeidsmatig', respectively. Less significant and lowly correlated behavior is discarded from the process model, i.e. nodes and arcs which fall into this category are removed from the graph. Coherent groups of less significant behavior, which is however highly correlated, is represented in aggregated form, as clusters. Cluster nodes are represented as green octagons, displaying the mean significance of the clustered elements and their amount. The internal components of clusters and their structure can be explored by clicking on the green cluster nodes. Links, or arcs, drawn between nodes are decorated with the significance and correlation represented by each relation. Additionally, arcs will be colored in a grey shade, the lower the significance of the relation the lighter the grey (www.processmining.org).

4.2.2.2 Process analysis

In this paragraph the selected process analysis plug-ins ‘performance sequence diagram’, ‘dotted chart analysis’, ‘originator by task matrix’, and ‘log summary’ are described.

Performance sequence diagram

The purpose of the performance sequence diagram plug-in is to provide information about the performance of processes. As an example the pattern diagram of closed care trajectories filtered on a level 1 naming level of the GGzE Centre child and adolescent psychiatry is depicted in appendix I figure 34. This pattern diagram displays the patterns sorted on the frequency of sequences that follow the pattern (the pattern with the highest frequency is displayed at the top). Furthermore, information such as the mean throughput time of the patterns is available. This can be used to determine which patterns appear often, and thus seem to be common behavior, which not (rare, maybe even unwanted, behavior) and which patterns result in a high throughput time, and thus may indicate unwanted behavior. Because of the complexity of care delivery processes there is chosen to use the flexible-equivalent pattern type, which provides information about the composition of the patterns regardless of the sequence of activities.

When taking a closer look at the performance sequence diagram depicted in appendix I figure 34 we found that there are 91 different paths, i.e. combinations of activities, a client can follow. The analysis is based on 2127 cases, i.e. care trajectories. The ten most frequent paths, their frequency, and their throughput times and standard deviation are depicted in table 3. The ten most frequent paths account for 86 % of all care trajectories in the dataset (1822 out of 2127). They have an average throughput time of 236 days.

Table 3 Ten most frequent paths analyzed by means of performance sequence diagram

Path activities	*Frequency*	*Average throughput times (days)*	*Standard deviation throughput times (days)*
Algemene indirect tijd – Behandeling – Diagnostiek	553	356	183
Algemene indirect tijd – Behandeling	490	251	165
Algemene indirect tijd	206	55	98
Algemene indirect tijd – Behandeling – Diagnostiek – Pré intake	140	305	103
Behandeling	113	91	127
Algemene indirect tijd – Diagnostiek	107	188	143
Diagnostiek	84	27	70
Algemene indirect tijd – Diagnostiek	50	163	225
Algemene indirect tijd – Diagnostiek – Pré intake	42	193	126
Algemene indirect tijd – Behandeling – Verblijf – Diagnostiek	37	199	130

Dotted chart diagram

The dotted chart can be used to show to overall events and performance information in the log. The most important application of the dotted chart for the case study at GGzE Centre child and adolescent psychiatry has already been described in section 3.5.3.2 figure 14 (model generated by ProM) and section 4.2.1.3 (visualization by MagnaView). Recall that this dotted chart application depicts the care trajectories ordered at ascending relative duration along the Y-axis, and the sequence of activities are shown along the X-axis. The next section describes how this particular dotted chart application can be used in order to identify client groups.

Within this paragraph another application of the dotted chart diagram generated by ProM will be explained. This concerns a dotted chart analysis from the ‘task perspective' (instead of from the ‘case perspective’). Appendix I figure 35 shows an example dotted chart analysis of closed care trajectories filtered on a level 1 naming level of the GGzE Centre child and adolescent psychiatry. In this diagram the main activity groups ordered at ascending number of events are depicted along the Y-axis. The time option ‘relative time’ has been used, which shows the duration from the first activity to a certain next activity, i.e. the diagram tells us something about the spread of the activities along their care trajectories recorded in the log file. As a summarization table 4 depicts the activity groups, the number of occurred activities, and the time measures: first activity occurrence (which is in this case always 0), last activity occurrence, average interval, minimal interval between two successive activities, and maximum interval between two successive activities. Unfortunately, no variability statistics (variance of standard deviation) are presented in the dotted chart analysis plug-in. From table 4 can be concluded that most activities are of the category 'behandeling', 'algemene indirecte tijd', and 'verblijf'. The activities 'begeleiding' and 'dagbesteding' usually occur within the first year of a care trajectory, other activities have a higher spread over time. Especially the high spread of 'pré intake' activities is notable, since it was expected that this type of activity only occurs at the very beginning of a care trajectory.

Table 4 Main activity groups and their time measures based on 'relative time' dotted chart diagram

Activity group	*Number of occurrence*	*Time first (days)*	*Time end (days)*	*Average interval (days)*	*Minimal interval (days)*	*Maximum interval (days)*
Begeleiding	131	0	346	2.66	0.00	19.00
Crisisopvang	189	0	671	3.57	0.00	94.96
Dagbesteding	387	0	414	1.07	0.00	21.00
Pré intake	429	0	907	2.11	0.00	253.96
Diagnostiek	3941	0	927	0.23	0.00	84.96
Verblijf	10025	0	574	0.06	0.00	90.00
Algemene indirecte tijd	16742	0	949	0.06	0.00	22.92
Behandeling	18507	0	969	0.05	0.00	28.00

Originator by task matrix

Another interesting analysis application, which is also supported by the MagnaView PAS project, is the originator by task matrix. This analysis plug-in shows how frequently each originator conducts specific activities. In appendix I figure 36 the originator by task matrix with level 2 activities and level 2 originator coding is depicted. Note that activities executed by more than 1 resource are grouped and resources are renamed as "multiple_*name level1 activity*". Furthermore, this matrix is generated from a log file where the following filters are applied: pervasive diagnosis only, care trajectories containing more than 5 activities, and no waiting times longer than 60 days. In the matrix the most frequent executed tasks by a specific originator group are colored dark green; the less frequent the particular combination occurred, the lighter the cell is colored. The matrix in figure 36 depicts that combinations with activity 3.1, which is 'communicatieve behandeling', occur most often. Especially AG.SF, PB.BG, VB.BG, VB.SF, and multiple_behandeling are executers of activity 3.1. The meaning of this profession codes are included in appendix G 'Coding activities and employees'.

Log summary

An analysis plug-in which certainly should not be absent when discussing ProM analyses is the 'log summary'. The log Summary provides an overview about meta data and simple frequency statistics for a log. The most important statistics used in the next section are: relative and absolute occurrence of log events, i.e. activities; relative and absolute occurrence of starting log events of a care trajectory; relative and absolute occurrence of ending log events of a care trajectory; and relative and absolute occurrence of originators. Because of the size of a (.html) log summary no illustration is depicted in this report. Like already mentioned the processed results from the log summaries are discussed in section 4.3.

4.3 Identification of client groups

In the previous section has been shown that MagnaView and ProM provide a number of analyses in order to clarify process characteristics, bottlenecks and process patterns. However, Vissers (2006) argues that from an operations management perspective, a product classification approach is required when aiming at healthcare process improvement. Ultimately, iso-process groups should be identified, meaning that patient groups are distinguished fulfilling the homogeneity criteria in terms of process and market performance (section 2.3.1). In order to make an attempt to identifying iso-process groups a closer look at the 'Relative duration of care trajectories' visualization of MagnaView (section 4.2.1.3) has been taken. By means of a brainstorm session with GGzE project manager care logistics management, there has been hypothesized that differences between trajectories exist with regard to the characteristics throughput time and (total) processing time, i.e. direct and indirect client bounded time. This hypothesis is based on the conspicuous difference in shape of the 'Number of activities per care trajectory' (appendix L, sheet 17-19) on the one hand, and the ''Relative duration of care trajectories' (appendix L, sheet, 22-26) on the other hand. Like already explained in section 4.2.1.3 the 'Number of activities per care trajectory' –curve is characterized by a negative exponential distribution, i.e. concave shaped, whereas the 'Relative duration of care trajectories'–curve is characterized by a belly distribution, i.e. spherical shaped.

4.3.1 Distinction by throughput times and number of activities

By means of visual grouping the diagram in figure 20 has been constructed. In this diagram the total group of clients is divided into four main groups based on throughput time and total processing times (i.e. number of activities) characteristics. The diagram implies that the following four main client groups can be identified: rapid discharge, long-term no treatment, diagnostic complex severe psychosocial and psychiatric disorders, and general severe psychological and psychiatric disorders. An explanation of the characteristics of these client groups is given below the graph.

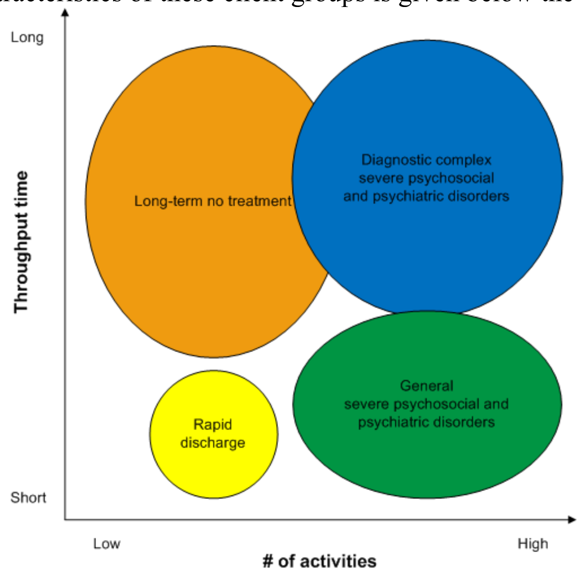


Figure 20 Client groups classified on number of activities and throughput time

Rapid discharge

This group of clients is not part of the target group of GGzE since their disorders are not in line with GGzE's core business/best practices. It is expected that this group of clients accounts for only a few DBC activities; this means low total processing time. Furthermore it is expected that the total treatment time (i.e. throughput time) is generally very short and has little variation. If the throughput time appears to be longer than logically this is caused by waiting time but not by the number or the duration of activities. Moreover, the expectation is that the activities within the 'rapid discharge'-group are mostly indirect, that is without presence of client, and that those activities mostly comprehend consultation of specialists together. The directive of discharge of these clients should be one week.

Long-term no treatment

This group of clients is regarded as inferior for treatment processes at GGzE Centre child and adolescent psychiatry: they enter the centre and are not seen by a specialist for a long time because it is assumed that it is not needed or that they already finished their treatment. However, at a later point in time they enter the treatment processes again.

It can be visually analyzed that this group is represented in the bottom of the 'relative duration of care trajectories' –graph since some open spots have appeared due to low density of activities in time. However, it is expected that this group of clients is present through the whole chart. Since it is expected that this group of clients accounts for a major part of Patient in Process (PIP), i.e. a concept analog to the Work in Process (WIP) measure in manufacturing which focuses on reducing throughput time, more efficient resource utilization, and cost saving (Kujala et al.,2006), it is very important to detect this group of patients. Typically, in lean thinking terms, this group of clients causes 'waste' in the care delivery processes of GGzE, i.e. they interfere a conveniently arranged overview of the processes.

General severe psychosocial and psychiatric disorders
This group of clients is regarded as the target group of GGzE, that is, these clients suffer from severe psychosocial and psychiatric disorders and need treatments offered by GGzE. Although their disorders are complex the treatment process is relative clear; in the best case they can be easily diagnosed and the treatments following are obvious. In terms of processing times it is expected that those clients have a high total processing time, characterized by many contacts (i.e., activities 3, 4, 5, 6 which are defined in appendix G) and less consultation of specialists together (i.e., activities 1 and 7). The throughput times can be short or middle long but are generally shorter than those of clients which are diagnostic complex.

Diagnostic complex severe psychosocial and psychiatric disorders
This group of clients is the second target group of GGzE. Like 'General severe psychosocial and psychiatric disorders', these clients suffer from severe psychosocial and psychiatric disorders and need treatments offered by GGzE. Although there are several similarities between these groups, they differ in the complexity of the treatment process. For this groups of clients it is difficult to determine the right diagnosis (the first time), moreover the treatments the clients should follow are not obvious. In terms of processing times it is expected that those clients have a high total processing time, characterized by many contacts (i.e., activities 3, 4, 5, 6). It is expected that for this group more consultation of specialists together (i.e., activities 1 and 7) is done than for the group "General severe psychosocial and psychiatric disorders". Furthermore, the dotted chart diagram shows us relative frequently appearance of "act 2" activities which point to the abundance of diagnostic activities. The throughput times are middle long or long.

Although there are other possibilities of client grouping, e.g. diagnosis, ambulant/clinical, etc.), first the "target group" of GGzE Centre child and adolescent psychiatry should be identified. This is done by dividing the total group of clients into four main groups based on the characteristics throughput time and number of activities (i.e. direct and indirect client bounded time).

4.3.2 Verification of client groups

In order to verify if the hypothesized client groups really exist, an analysis based on the method described in section 3.1 has been performed. The steps executed are depicted in figure 21. In the remaining of this section the results of step 1 and step 8, which are 'client group process indicators', 'classification of client group', and 'analysis of client groups', will be discussed.

(1) Define client group process indicators.
(2) Based on these indicators, filter care trajectories out of 'relative duration of care trajectories'–graph in MagnaView.
(3) Export .txt files, containing attributes in line with MSAccessPlugin for ProM, by means of MagnaView.
(4) Import .txt files in MSAccessPlugin for ProM.
(5) Convert data into MXML log file.
(6) Load MXML log files in ProM and generate the following analyses: Log summary, Dashboard statistics, and dotted chart analysis.
(7) Copy data from log summaries in MS Excel in order to compare the characteristics of the client groups.
(8) Present results by means of summary graphs in MS Excel.

Figure 21 Steps in order to verify hypothesized client groups

4.3.2.1 Client group process indicators

During brainstorm sessions with GGzE project manager care logistics management and discussions during presentations with experts (see further section 4.4), a number of process indicators are selected in order to identify client groups. These process indicators are mainly based on the filter options of the MagnaView PAS-GGZ project defined in section 3.6, and are the following:

- Primary diagnosis performance, that is, no distinction in diagnosis versus pervasive diagnosed.
- Client age, that is, younger than 12 years versus 12 years old and older.
- Care trajectories which contain five or less versus more than five activities.
- Care trajectories with waiting times between two activities shorter than 30/60/90 days versus at least 30/90 days.

Since taking all combinations of these filer options into account would be excessively and too time-consuming, a selection has been made. The chosen combinations are depicted in table 5. Furthermore, there should be noticed that for this analysis only closed care trajectories are considered, the activities and professions are set a level 2 coding level, and activities executed by more than 1 resource are grouped and resources are renamed as 'multiple_*name level1 activity*' (which has been described in section 3.3). Table 5 depicts a colored rectangle for all processed log files. Moreover, these rectangles contain the number of care trajectories and the number of activities present in the log file.

Table 5 Client group process indicators and main log file characteristics

		All	Primary diagnosis: pervasive		
			All	≥ 12	< 12
All		# CT 2127 # act 50351	# CT 899 # act 16112	# CT 456 # act 10027	# CT 443 # act 6085
> 5 activities	All	# CT 1396 # act 48500	# CT 568 # act 15330	# CT 281 # act 9626	# CT 287 # act 5704
	< 30 days waiting time	# CT 191 # act 19091	# CT 47 # act 3566	# CT 34 # act 3029	
	< 60 days waiting time			# CT 102 # act 5506	
	< 90 days waiting time	# CT 761 # act 35418	# CT 274 # act 9674	# CT 155 # act 6934	# CT 119 # act 2740
	≥ 30 days waiting time	# CT 1205 # act 32409	# CT 521 # act 11764		
	≥ 90 days waiting time	# CT 635 # act 13082	# CT 294 # act 5656	# CT 126 # act 2692	# CT 168 # act 2964
≤ 5 activities		# CT 731 # act 1851	# CT 331 # act 782	# CT 175 # act 401	# CT 156 # act 381

In the next two paragraphs the log files of table 5 will be used in order to classify client groups (section 4.3.2.2) and perform an analysis of these groups (section 4.3.2.3). However, from table 5 already some interesting conclusions can be stated about the relative size of the client groups. For example, the care trajectories' group in which all diagnostic groups and all activities are present contains 2127 closed care trajectories. From this total group, about one-third only contains 5 or less activities. Furthermore, less than 15 percent of this other two-third has a maximum waiting time of 30 days between two successive activities, and (complementary) more than 85 percent of the care trajectories which have more than 5 activities contain at least one succession with a waiting time longer than 30 days. Moreover, for about half of the care trajectories containing more than 5 activities holds that at least one succession of activities takes more than 90 days.

4.3.2.2 Classification of client groups

In order to classify client groups the statistics from each log file depicted at the 'Dashboard'-analysis in ProM (for an example screenprint see figure 13 section 3.5.2) and the 'Dotted chart' -analysis in ProM (for an example screenprint see figure 14 section 3.5.3.2) , are summarized in a MS Excel table, which is depicted in appendix J table 7. In this table the following statistics for each log file are presented: # of care trajectories, # of DBCs, # of activities, # of activity types, # of originators, # of activities per care trajectory (mean, min, max), # of activity types per care trajectory (mean, min, max), and throughput time of care trajectories in days (mean, min, max). Furthermore two additional statistics are calculated which are: mean throughput time of a care trajectory divided by the mean number of activities per care trajectory, and the mean number of activities per care trajectory divided by the mean throughput time of a care trajectory. Moreover, the colors depicted in table 5 are also added to each row (representing a log file) in table 6 appendix J.

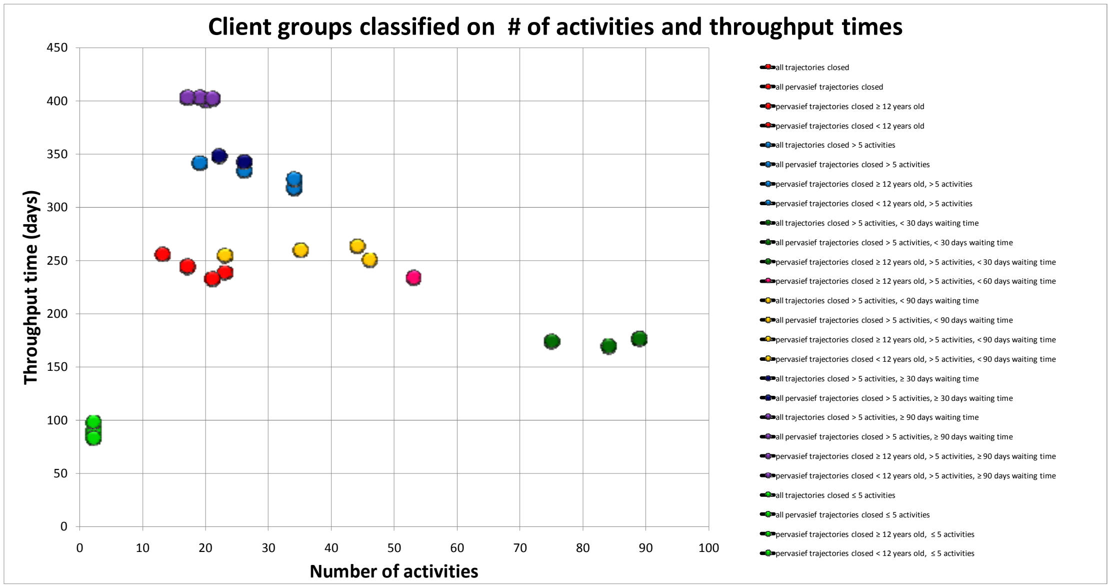


Figure 22 Client groups classified on # of activities and throughput times

By means of table 7 the classification diagram depicted in figure 22 has been designed. In this diagram the client groups are classified on the mean number of activities per care trajectories (depicted on the X-axis) and the mean throughput times in days of a care trajectory (depicted on the Y-axis). In this diagram the assigned colors form clusters, indicating that care trajectories in these log files are characterized by roughly the same mean throughput time and number of activities. Indexed by color the following conclusions from the diagram in figure 22 can be stated:

- Vertically centered at the left side the red cluster has been depicted. This cluster represent log files where 'all' activities are depicted, meaning that no distinction has been made between care trajectories with more than 5 activities, or less and equal than five activities. This cluster indicates that no major differences exist, concerning mean throughput time and number of activities, regarding pervasive diagnosis and clients which are younger/older than 12 years. This phenomenon is not only represented by the red cluster, but actually all clusters indicate that there are no major differences regarding clients having a pervasive diagnosis and are younger/older than 12 years.
- Fairly close to the red cluster the yellow cluster is depicted. The care trajectories within this cluster all contain more than 5 activities and have no waiting times between two successive activities longer than 90 days. Being that close to the red cluster indicates that the yellow cluster best represents the average care delivery processes of GGzE Centre child and adolescent psychiatry.
- Looking at the upper part of the graph, the purple cluster, dark blue cluster, and light blue cluster could be identified. These clusters all contain more than five activities and are characterized by more than 90 days of waiting time, more than 30 days of waiting time, and no waiting time specifications, respectively, between two successive activities in a care trajectory. From this could be concluded that the higher the maximum waiting time between two successive activities, the higher the mean throughput time of that care trajectory.
- The cluster with by far the lowest throughput time and number of activities is depicted in light green. Like we already could suspect, this cluster is characterized by care trajectories which have no more than five activities.

- The dark green cluster lies farthest from the red cluster, which indicates that this cluster causes most variation in the number of activities when considering ‘all’ care trajectories. Typically, the green cluster is characterized by care trajectories containing more than 5 activities and have no waiting times longer than 30 days between two successive activities.

Based on the above classification, it is interesting to state some conclusions about the ‘efficiency’ of client groups. The measure used for efficiency is the mean number of activities per care trajectory divided by mean throughput time in days of a care trajectory. As a result an efficiency of 1.00 means that on average one activity per day is registered, likewise, an efficiency of 0.10 means that on average one activity per 10 days is registered. The graph in figure 23 depicts the efficiencies of client group care delivery processes. Taking a closer look at this graph it can be concluded that care trajectories containing more than 5 activities and have no waiting times longer than 30 days between two successive activities (dark green cluster) are far most efficient compared to the other client groups. The less efficient are the care trajectories part of the light green cluster, which are characterized by care trajectories containing no more than five activities, i.e. rapid discharge defined in section 4.3.1.

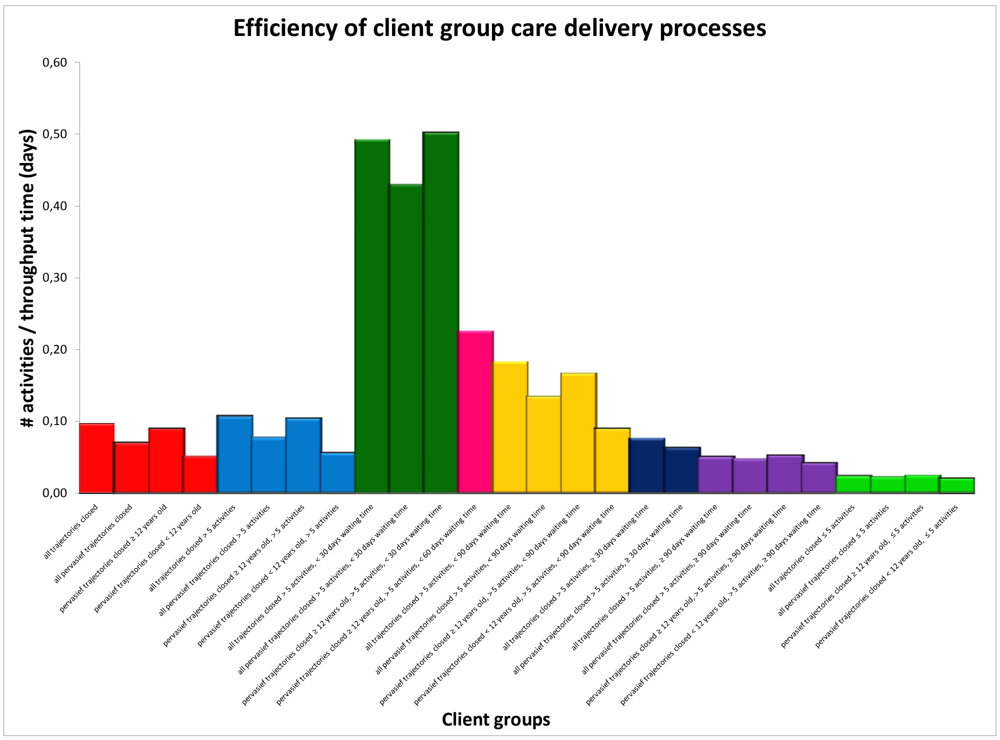


Figure 23 Efficiency of care delivery processes classified on client group characteristics

4.3.2.3 Analysis of client groups

In the previous section a classification of client groups has been made and aggregated performance data with regard to these groups have been calculated and visualized. Within this section the client groups will be analyzed in more detail. In particular, first the activities and originators present in each group have been identified, and second an analysis concerning variability within client groups has been performed.

Activities and originators of client groups
In order to identify which activities and originators are present in the client groups (i.e. log files) the ‘log summary’-anaysis has been used. For each log file the following statistics have been summarized in MS excel tables: relative and absolute occurrence of log events, i.e. activities; relative and absolute

occurrence of starting log events of a care trajectory; relative and absolute occurrence of ending log events of a care trajectory; and relative and absolute occurrence of originators. A number of these tables are depicted in appendix J. In figure 24 the relative occurrence of activities at a level 1 coding level ordered at client groups are depicted in a bar chart.

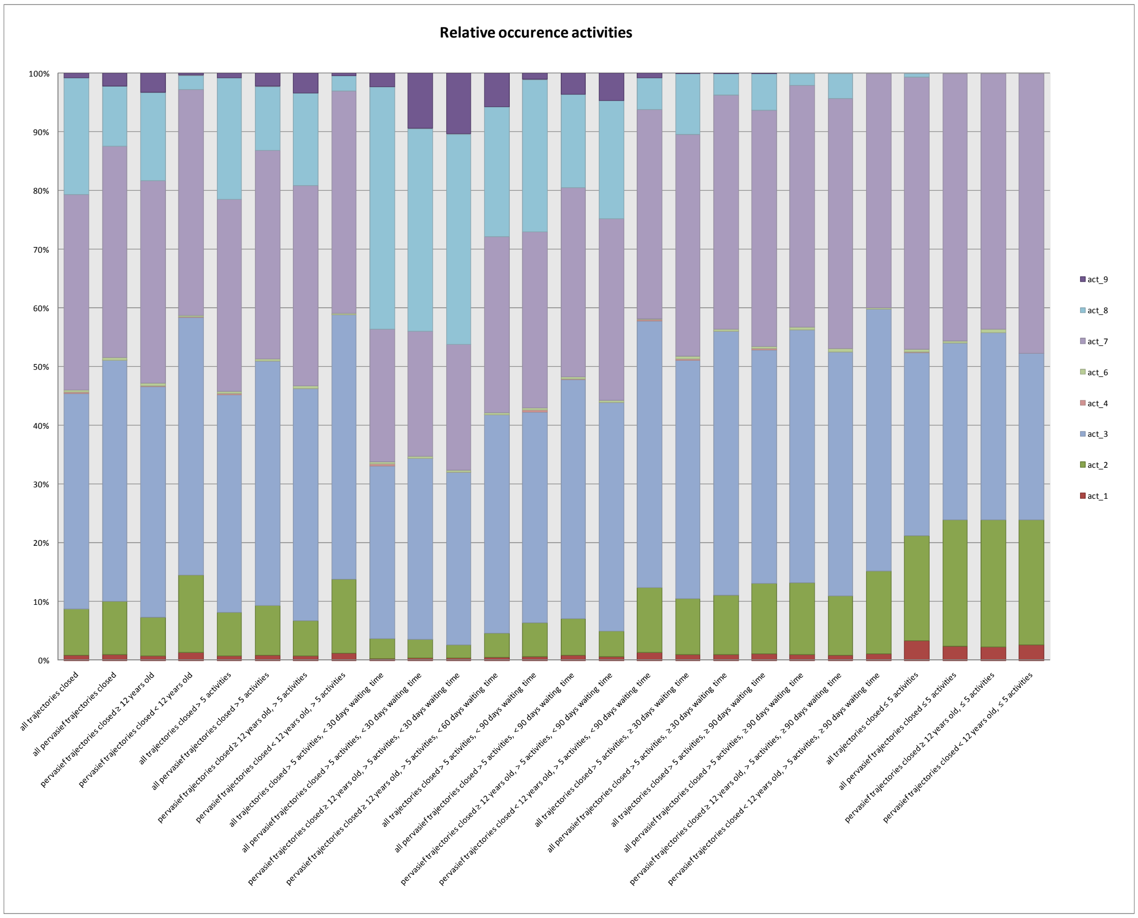


Figure 24 Relative occurence activities at a level 1 coding level ordered at client groups

From this graph the following conclusions can be stated:

- Activity 1 'Pré intake' accounts for only 0.85% of the activities when all close care trajectories are considered. The relative occurrence of this event is highest for the group containing 5 or less activities, i.e. rapid discharge, and amounts 3.30% of the activities. The relative occurrence is lowest for the group which is characterized by care trajectories containing more than 5 activities and have no waiting times longer than 30 days between two successive activities, that is 0.24%.
- Activity 2 'Diagnostiek' accounts for 7.83% of the activities when all closed care trajectories are considered. Again the relative occurrence of this event is highest for the rapid discharge group, and amounts 17.94% of the activities. The relative occurrence is lowest for the group which is characterized by care trajectories containing more than 5 activities and have no waiting times longer than 30 days between two successive activities, that is 3.38%.
- Activity 3 'Behandeling' accounts for most activities when all closed care trajectories are considered, that is 36.76%. The relative occurrence is highest for the group which is characterized by care trajectories containing more than 5 activities and have at least once a waiting time between two successive activities longer than 30 days, that is 40.67%. The relative occurrence is lowest for the group which is characterized by care trajectories containing more than 5 activities and have no waiting times longer than 30 days between two successive activities, that is 29.51%.
- Activity 4 'Begeleiding' accounts for only 0.26 % of the activities when all close care trajectories are considered. The relative occurrence of this event is lowest for the group containing 5 or less

activities, and amounts 0.05% of the activities. Comparing the other client groups, the relative occurrence of activity 4 does not differ much.

- Activity 6 ‘Crisisopvang’ accounts for only 0.38% of the activities when all close care trajectories are considered. The difference in relative occurrence is not large between the several client groups.
- The second frequent occurred activity is activity 7 ‘Algemene indirecte tijd’, and accounts for 33.25% when all care trajectories are considered. For the client groups characterized by care trajectories containing more than 5 activities and have at least once a waiting time between two successive activities longer than 90 days, and the group containing 5 or less activities, activity 7 has the highest relative occurrence with 40.23% and 46.41%, respectively. The relative occurrence is lowest for the group which is characterized by care trajectories containing more than 5 activities and have no waiting times longer than 30 days between two successive activities, that is 22.58%.
- Activity 8 ‘Verblijf’ accounts for 19.91 % of the activities when all close care trajectories are considered. Remarkable is that this activity occurred by far most within the client group characterized by care trajectories containing more than 5 activities and have no waiting times longer than 30 days between two successive activities, that is 41.27%. Like could be expected ‘Verblijf’ does not frequent appears in the client group rapid discharge (0.59%).
- Activity 9 ‘Dagbesteding’ is not often present in the log files, when all closed care trajectories are considered ‘Dagbesteding’ occurred in 0.77% of all activities. This activity was most present in care trajectories which do not have high waiting times between two successive activities.

In order to validate the client group analysis, figure 24 has been presented and discussed to managers and experts of GGzE Centre research and development (O&O). This is depicted in appendix L sheet 30. In addition the presentation contained analysis graphs of the relative occurrence of activities at a level 2 coding level (sheet 31) and the relative occurrence of originators at a level 1 coding level (sheet 32). From these analyses can be concluded that the largest difference between client groups with regard to activities compounding and resource constellation exist in the clusters which are characterized by care trajectories containing 5 or less activities (i.e. rapid discharge), and by care trajectories containing more than 5 activities and have no waiting times longer than 30 days between two successive activities. From these client groups the variability of processes characteristics are discussed next.

Variability within client groups

For gaining more insight in the variability of the processes of distinct client groups the ‘Dashboard’-analysis and ‘Dotted chart’-analysis of ProM can be consulted. Appendix K depicts these analyses for the following client groups:

- All closed care trajectories
- Care trajectories with 5 or less activities (rapid discharge)
- Care trajectories containing more than 5 activities (complement of rapid discharge)
- Care trajectories with more than 5 activities and waiting times smaller than 30 days
- Care trajectories with more than 5 activities and at least one succession with waiting times larger than 90 days (long-term no treatment)

Taking a closer look at the dotted charts it can be concluded that almost all care trajectories are closed within one year when it concerns the rapid discharge group and when the waiting times between two successive activities is always smaller than 30 days. Like already concluded, the later also has the highest activity density and can therefore be considered as the most efficient care delivery process. Containing most ‘Verblijf’ activities, it is expected that most priority is ascribed to this client group by GGzE. Comparing this result to the dotted chart characterized by care trajectories with more than 5 activities and at least one succession with waiting times larger than 90 days, some major differences can be seen. The care trajectories of the client group which faces long waiting times often takes longer than one year, although these care trajectories on average contain less activities.

To conclude this section, it can be stated that indeed a distinction of client groups can be made based on the number of activities and the throughput time of care trajectories. In particular, the client groups 'rapid discharge' and 'long-term no treatment' can be distinguished. The rapid discharge group accounts for 34% of the total care trajectories, and only 4% of the total performed activities included in the dataset. The long-term no treatment, i.e. time between two succesive activities ≥ 90 days, accounts for 30% of the total care trajectories, and for 26 % of the total performed activities. The remaining 36% of the care trajectories are expected to be the target group of GGzE, which are named: 'General severe psychosocial and psychiatric disorders' and 'Diagnostic complex severe psychosocial and psychiatric disorders' (section 4.3.1). However, within this group another interesting group can be distinguished which is the group of client processes characterized by care trajectories with more than 5 activities and where the time between two successive activities is always smaller than 30 days. In particular, this group amounts only 9% of the total care trajectories, but accounts 38% of the total performed activities in the data set. By means of comparing the activity compounding and originator constellation within the client groups processes, it is found that the group with small waiting times between activities are characterized by a relative high number of 'verblijf' and 'dagbesteding' activities, whereas client groups with at least one high waiting time between activities are characterized by a relative high number of 'diagnostiek', 'behandeling', and 'algemene indirecte tijd' activities. Although the 'rapid discharge' group only amounts a relative few activities, it can be concluded that for this group relative a lot time is spend at 'diagnostiek' and 'algemene indirecte tijd' activities. In order to gain more insight of the characteristics of the target group of GGzE additional analyses should be done.

4.4 Validation of case results

In order to validate the case results a number of presentations including discussions with several stakeholders and involved parties have been organized. In particular the MagnaView visualizations discussed in this chapter and the identification of client groups has been presented. The target groups of the presentations where: managers and professionals of GGzE Centre child and adolescent psychiatry (K&J), managers and professionals of GGzE Centre research and development (O&O), GGzE project manager care logistics management (Tom Joosten), TU/e supervisors (Monique Jansen-Vullers and Ad Kleingeld), and MagnaView experts. In order to validate the analyzed results in an organized manner, there is chosen to present the results by means of a MS Powerpoint presentations. The structure of the presentation remained to a large extend unchanged. Only adjustments as result of feedback and more in dept research (i.e. client group identification) have been added over time.

Table 6 lists the sheets depicted in appendix L 'Cliëntstromen in GGzE Centrum Kinderen en Jeugdpsychiatry (client flows in GGzE Centre child and adolescent psychiatry)'. Vertically the audience is listed, and in the table the sheets presented and/or discussed are marked. In particular there is evaluated whether the results of the analysis are understandable, relevant in order to analyze care delivery processes, and contribute to future process improvement. Furthermore, additional attention is payed at the verification of filter measure, i.e. (dis)aggregation of activities and employees, care trajectory characteristics, client characteristics, and chain logistics characteristics (section 3.6).

Unfortunately, the case results of specific ProM analysis (besides client group identification) are not validated by means of a presentation. These results only are presented and discussed with GGzE project manager care logistics management, and are evaluated positively. This will be further discussed in the next section 'evaluation of method'.

Table 6 Validation of case results by means of presentations and discussions

	Discussion of progress with GGzE supervisor (project manager care logistics management)	Intermediate presentation TU/e	Presentation GGzE Centre child and adolescent psychiatry	Discussion with specialists GGzE Centre child and adolescent psychiatry	Presentation and discussion MagnaView experts	Presentation GGzE Centre research and development
Title page	X	X	X	-	X	X
Inhoud	X	X	X	-	X	X
Introductie	X	X	X	-	X	X
Aanleiding onderzoek	X	X	X	-	X	X
Doel onderzoek	X	X	X	-	X	X
Scope	X	X	X	-	X	X
Zorgproces	X	X	X	-	X	X
Wachttijden veroorzaakt door variantie in	X	X	X	-	X	X
Aankomstpatroon cliënten centrum K&J	X	X	X	-	X	X
Doorlooptijden cliënten centrum K&J	X	X	X	-	X	X
Data analyse	X	X	X	-	X	X
Data analyse gebaseerd op DBC data	X	X	X	-	X	X
Complexiteit van zorgprocessen K&J	X	X	X	-	X	X
Procesmodel alle processen centrum K&J	X	X	X	-	X	X
Procesmodel klein stukje ingezoomd	X	X	X	-	X	X
Conclusie	X	X	X	-	X	X
Hoe kunnen we meer inzicht verkrijgen?	X	X	X	-	X	X
Proces karakteristieken – overview	X	X	X	X	X	X
Aantal zorgtrajecten per primaire proces	X	X	X	X	X	X
Activiteiten en hun uitvoerders	X	X	X	X	X	X
Aantal activiteiten per primaire diagnose	X	X	X	X	X	X
Eerste activiteiten van een zorgtraject	X	X	X	X	X	X
Laatste activiteiten van een zorgtraject	X	X	X	X	X	X
Bottlenecks	X	X	X	X	X	X
Wachttijden per activiteit	X	X	X	X	X	X
Wachttijden per medewerker	X	X	X	X	X	X
Procespatronen	X	X	X	X	X	X
Aantal activiteiten per zorgtraject	X	X	X	X	X	X
Aantal activiteiten per zorgtraject – Aandachtstekort- en gedragsstoornissen (ADHD)	X	-	X	X	X	X
Aantal activiteiten per zorgtraject – Pervasieve ontwikkelingsstoornissen (autisme)	X	-	X	X	X	X
Relatieve tijdsduur van zorgtrajecten	X	X	X	X	X	X
Schematische weergave cliëntgroepen	X	-	X	X	X	X
Relatieve tijdsduur van zorgtrajecten – Filter > 5 activiteiten	X	-	X	X	X	X
Relatieve tijdsduur van zorgtrajecten – Filter > 5 act. en wachttijd tussen act. < 60 dagen	X	-	X	X	X	X
Relatieve tijdsduur van zorgtrajecten – Filter > 5 act. en wachttijd tussen act. > 60 dagen	X	-	X	X	X	X
Relatieve tijdsduur van zorgtrajecten – Filter > 5 act. en w.t. tussen act. < 60 dg. autisme	X	-	X	X	X	X
Relatieve tijdsduur van zorgtrajecten – Filter > 5 act. en w.t. tussen act. > 60 dg. Autisme	X	-	X	X	X	X
Cliëntgroepen	X	-	X	X	X	X
Aanvullende analyse cliëntgroepen	X	-	-	-	-	X
Client groups classified on # of activities and throughput times	X	-	-	-	-	X
Efficiency of client group treatment processes	X	-	-	-	-	X
Relative occurrence activities	X	-	-	-	-	X
Relative occurrence originators	X	-	-	-	-	X
Vragen / discussie	X	X	X	X	X	X

Legend:
X = presented and/or discussed;
- = not presented or discussed.

4.5 Evaluation of method

The data-based method described in chapter 3 and applied during a case study at GGzE Centre child and adolescent psychiatry has been positively evaluated by managers and professions during presentations and discussions; this has been described in the previous section.

Furthermore, an additional meeting with GGzE supervisor T.C.M. Joosten (who also is GGzE project manager care logistics management at GGzE Centre research and development) was planned in order to evaluate particular aspects of the method. First the following criteria set by Riemers (2009) were evaluated:
1. The results should be presented within limited time.
2. Process models should have a high fitness.
3. The approach should be positively evaluated by the medical specialists and managers.
4. The results should be simple to understand for the medical specialists and managers.
5. Interactive analysis should be possible.
6. The analysis should focus on certain aspects of the treatment process.

According to Joosten all criteria were met; the presentations Cliëntstromen in GGzE Centrum Kinderen en Jeugdpsychiatry (client flows in GGzE Centre child and adolescent psychiatry)', serve as proof. In particular there was concluded that the main advantages of data visualization are: (i) a better understanding about the process; and (ii) a better understanding about bottlenecks within the process.

In addition, the results have a positive effect on managing processes at GGzE Centre in child and adolescent psychiatry, because: (i) Managers and profession gained insight about what really happened in their processes by means of analyses of data they registered themselves (for the first time); and (ii) these insights support the desire for structural process improvement and better registration of what really occurred during care delivery processes.

With respect to the content of the method, it was already stated that validation mainly has been based on results gained by means of MagnaView. However the combination of visual analytics and process mining has been evaluated positively, since there is agreed that application of ProM offers an additional advantage compared to MagnaView due to the fact that process mining offers process related information by looking at the inside of the process, while MagnaView mainly has been used to present statistical information in a clearer way. For GGzE Centre research and development in particular, the data-based method is of relevance, because: (i) it enables researchers to logically aggregate process data and obtain purposeful process analyses, and (ii) based on these analyses, care delivery processes could be better controlled, which serves as starting point for future process improvement. Moreover, the great potency of visualizing process characteristics has already leaded to implementation of the PAS project at GGzE. Based on the PAS-GGZ project, including the designed dataset during this master thesis project, MagnaView B.V. has started to offer their serves to GGzE in order to analyze the most recent and future DBC-GGZ data.

In general it could be stated that both the case results as well as the method are evaluated positively. Nevertheless, there are still some points of discussion with regard to the method. Next, two points with regard to the choice of the process indicator waiting time and those used for clustering and filtering are discussed.

The first point of discussion concerns the choice of the process indicator waiting time. In the PAS-GGZ project the waiting times has been calculated by means of the time difference between two activities. Although this is the only possible measure when DBC-GGZ data is concerned the indicator cause a deal of controversy because of two reasons. First, typically mental healthcare delivery deals with passive care times and positive waiting times like discussed by Kujala et al. (2006). Second, this waiting time measure typically calculates the time between two successive events, however, it does not tell the difference between demand and delivery. If for example a specific diagnostic activity has been requested, but a client has been putted on a waiting list and in the mean time some other activities take place, the calculated measure does not give an accurate description of the actual waiting time.

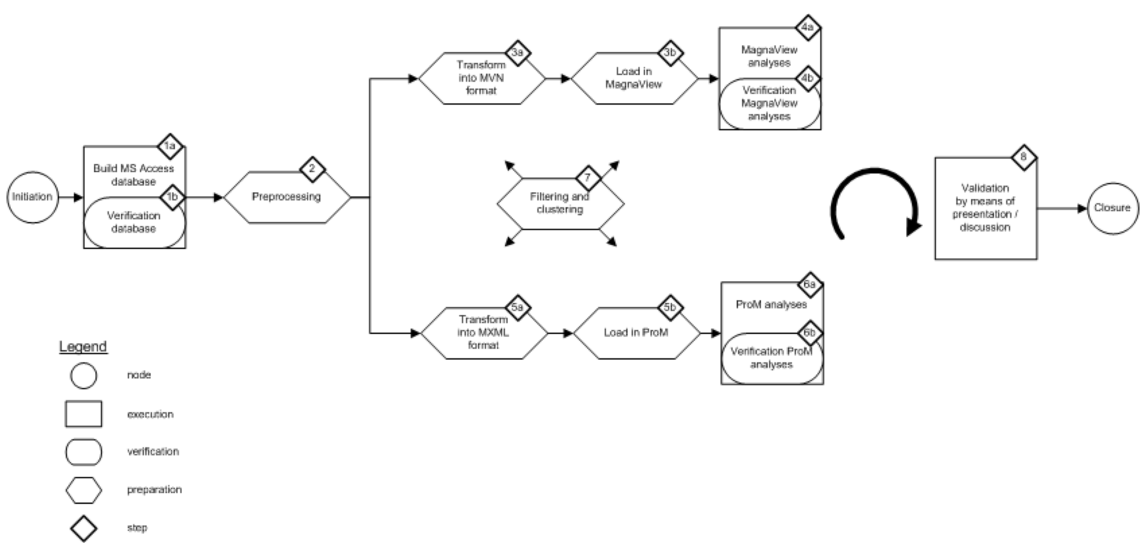
The second point of discussion concerns the choice for the process indicators used for clustering and filtering. Although auditors reacted positively on the presented results, it is recommended to take into consideration whether for example the ‘primary diagnosis’ groups lead to sufficient accurate results for classifying care trajectories with regard to defining iso-process client groups. Furthermore the distinction clinical and ambulant should be made when classifying client groups. Moreover, one can wonder if classification at the care trajectory level is most appropriate, or that perhaps classification on a DBC level offers much more opportunity (e.g. by means of code lists) to identify iso-process patient groups. Very recently, GGzE Centre research and development has started to define treatment programmes. With those treatment programmes GGzE aims at analyzing and controlling care delivery processes at a meso-level which is situated between the macro-level represented by care trajectories and the micro-level representing the several activities. An example of a newly defined treatment program is ‘coaching ADHD’. Remark that when implementation of such treatment programmes is mature, the process analysis method can be used to in order to compare the output of the processes before and after process improvement initiatives.

5 Conclusions and recommendations

Managers and professionals of GGzE Centre child and adolescent psychiatry are of the opinion that more measures, especially about specific processes and process phases, are desired for managing their processes. In order to deal with this problem the following research question has been formulated:

"Which method can be used to analyze data about care delivery processes in GGzE Centre child and adolescent psychiatry at a level that client flows can be identified and design solutions for logistical improvement can be developed?"

In order to answer the research question a number of project phases have been passed through, which are initiation, identification, analysis, design, and evaluation. During the identification phase first recent developments with respect to describing mental healthcare processes in general, and care delivery processes at GGzE Centre child and adolescent psychiatry in specific are described. Secondly, an existing method to analyze healthcare process has been introduced. Although this method developed by Riemers (2009) and validated by (Ramos Torres, 2009) has been designed for hospital settings, it has been based on DBC data, and therefore regarded as suitable for mental healthcare process analyses. The main advantage of the method developed by Riemers (2009) and validated by Torres Ramos (2009) is that it both utilizes process mining and visual analytics techniques. The combination of these techniques supposes complementary results due to the fact that process mining offers process related information by looking at the inside of the process while visual analytics can present this information in a clearer way. The tools proposed in the method for process mining and visual analytics are ProM and MagnaView, respectively. Furthermore, Riemers' method has proven to be relevant for both the control and diagnosis phases of the Business Process Management life cycle. However, for improving care delivery processes with regard to operational measures, a more specific logistical approach for process improvement should be used. A promising stepwise method for improving healthcare processes has been introduced by Vissers (2006). In particular Vissers (2006) emphasizes the need for identifying iso-process patient groups, for which a specific organization of services is developed. In addition the focused factory approach is discussed, which is in particular relevant since it is a widely tested concept in industry which emerges as a model for designing integrated care pathways (Joosten et al., 2008) and homogenous patient groups (Bertrand and de Vries, 2005).



During the analysis phase a case study at GGzE Centre children and adolescent psychiatry has been performed. Based on a reflection of the results obtained during the identification phase and analysis phase, a data-based method for mental healthcare analysis has been designed. The method is to a large extent based on the method of Riemers (2009), but differs in two important aspects: (1) for this method mental healthcare process data instead of hospital process data have been used; (2) where Riemers (2009) typically approaches a preliminary analysis and executes one iteration, the model designed for this master thesis project attempts to prescribe the required steps by means of a system approach, which is characterized by verification and validation steps and allows iteration. Typically, the method is designed in order to perform a case study which starts with initiation and ends with closure, like with projects in general. A graphical presentation of the method is shown at the previous page.

The first step depicted in the method is 'build database' in order to do so, first a database in MS Access should be designed and constructed. Input for this database is the DIS (DBC information system) files which are used for GGZ-DBC registration. In addition attributes from the code lists (CL codelijst) defined by the DBC systematic could be added in order to provide more specified and categorized information about the data elements. In order to make the database suitable for measuring operational aspects about client flows, some preprocessing activities should be performed. The method prescribes the concepts 'closed care trajectories' and 'multiple resources'. Next a choice for the branch of analysis should be made. In order to get the advantage of combining visual analytics and process mining, of course both branches should be passed through. In case of visual analytics by means of the MagnaView (MV) tool steps 3 and 4 should be performed. Step 3 consists of: (a) transforming the information stored in the MS Access database into the MagnaView data format 'mvn', and (b) linking the attributes of the MS Access database to the attributes of the MV PAS project. Although the PAS project seemed ultimately suitable for application within a healthcare setting, some views did not completely fit the DBC-GGZ data. Therefore some modifications had to be carried out. This resulted in a new PAS project called 'PAS-GGZ'. In step 4 the MagnaView analyses should be performed. Based on discussions with stakeholders a selection of views of the PAS-GGZ project has been made, in order to visualize the most relevant aspects of mental healthcare processes.

In case of process mining by means of the ProM tool the steps 5 and 6 should be performed. Step 5 consists of: (a) transforming the case information and information about the executed tasks stored in the MS Access database into the ProM MXML format, and (b) loading the from step 'a' resulted log files in ProM. In step 6 the ProM analyses should be performed. Based on other case studies applying ProM and the capabilities with regard to complexity of the mental healthcare processes a selection of mining plug-ins and analysis plug-ins has been made in order to discover the processes.

Particular attention should be paid on step 7 'filtering and clustering'. Due to complexity and inconveniently arrangement of healthcare processes, filtering and clustering techniques are needed in order to state conclusions about the processes and approach them more convenient. Ultimately, filtering and clustering techniques can be used in order to distinguish client groups fulfilling the iso-process patient group criteria (homogenous in terms of process and market performance). The filtering and clustering approaches applied on DBC-GGZ data are the following: (dis)aggregation of activities and employees, care trajectory characteristics, client characteristics, and chain logistics. Although filtering and clustering in principle can be applied at any moment on several parts of the method, filtering and clustering decisions are often a result of validation of previous analyses by stakeholders. Step 8 explicitly depicts this validation step. The method proposes that validation should be done by means of presentation and discussion of the process analyses results with involved parties such as managers and professionals of GGzE. By means of their feedback choices for new analyses (i.e. views or plug-ins), other filter/cluster capabilities, etc. could be made.

The data-based method for mental healthcare process analysis has been applied by means of a case study at GGzE Centre child and adolescent psychiatry. The application is based on DBC-GGZ data recorded at GGzE Centre child and adolescent psychiatry and delivered to DIS from November 2007 till November 2009. The results of the case study have been divided over four categories, which are: MagnaView analyses, ProM analyses, identification of client groups, and validation of case results.

The MagnaView analyses presented in the method are divided over the categories process characteristics, bottlenecks, and process patterns.

- Process characteristics related views are : arriving pattern of clients, throughput times of clients, number of care trajectories per primary diagnosis, activities and their originators, number of activities per primary diagnosis, and first and last activities or care trajectories.
- Bottleneck related views are: waiting times per activity, and waiting times per employee.
- Process patterns related views are: number of activities per care trajectory, and relative duration of care trajectories.

The selected plug-ins of ProM present in the method are the following:

- The selected mining plug-ins are: heuristic miner and fuzzy miner.
- The selected analysis plug-ins are: performance sequence diagram, dotted chart analysis, originator by task matrix, and log summary.

For identification of client groups a combination of both visual analytics and process mining has been used. The first step for the identification of client group was to visually analyze the 'relative duration of care trajectories view' during a brainstorm session with GGzE project manager care logistics management. Based on this analysis a diagram, containing four distinct client groups classified on throughput time and total processing times (i.e. number of activities) characteristics, has been designed. The four hypothesized client groups are: rapid discharge, long-term no treatment, diagnostic complex severe psychosocial and psychiatric disorders, and general severe psychological and psychiatric disorders. In order to classify the hypothesized client groups the filtering capability of MagnaView has been used to select care trajectories with certain characteristics. In particular the following filters are used: care trajectories containing more/less than 5 activities, longer/shorter waiting time (in days) between two successive activities, primary diagnosis, and client age. The first filter used is based on distinguishing care trajectories with more/less or equal than 5 activities. In particular the number 5 is chosen because route 1, i.e. the first operational phase of GGzE Centre child and adolescent psychiatry consists of 5 activities (Linkens, 2009). The cutoff point of 90 days has chosen, because there has been made the appointment within GGzE Centre child and adolescent psychiatry that clients who do not face treatment for 3 months should be deregistered and eventually later on registered with a new care trajectory ID. The measures 30 and 60 days are chosen intuitively, in order to get a better understanding about the efficiency and the composition of the processes with these characteristics. The primary diagnoses 'pervasieve ontwikkelingsstoornis' (autisme) has been chosen as filter option since this is with 44% of all care trajectories the largest diagnosed group. Finally, filtering on the client age 12 years and 12 years old and older is in line with classification used in organizing processes within GGzE Centre child and adolescent psychiatry.

In order to validate the case results a number of presentations including discussions with several stakeholders and involved parties have been organized. In particular the MagnaView visualizations and the identification of client groups have been presented. The target groups of the presentations where: managers and professionals of GGzE Centre child and adolescent psychiatry (K&J), managers and professionals of GGzE Centre research and development (O&O), GGzE project manager care logistics management, TU/e supervisors, and MagnaView experts. In order to validate the analyzed results in an organized manner, there is chosen to present the results by means of a MS Powerpoint presentations. The structure of the presentation remained to a large extend unchanged. Only adjustments as result of feedback and more in dept research (i.e. client group identification) have been added over time. In particular there is evaluated whether the results of the analysis are understandable, relevant in order to analyze care delivery processes, and contribute to future process improvement. Furthermore, additional attention has been paid at the verification of filter measure, i.e. (dis)aggregation of activities and employees, care trajectory characteristics, client characteristics, and chain logistics characteristics.

Unfortunately, the case results of specific ProM analyses (besides client group identification) are not validated by means of a presentation. These results are only presented and discussed with GGzE project manager care logistics management during an evaluation of the method. During this evaluation has been agreed that application of ProM offers additional advantages compared to MagnaView due to the fact that process mining offers process related information by looking at the inside of the process, while MagnaView mainly has been used to present statistical information in a clearer way.

Below some considerable findings of the case study are listed:

- The first finding concerns MagnaView analysis and is part of the process characteristic category presented by means of the 'throughput times of clients' –view. Remarkable about this graph is that the majority of care trajectories lasts less than 100 days, and only a few lasts a couple of years (up to 960 days). Furthermore, two bending curves can be distinguished; one at 365 days and one at 730 days. During discussions with experts it has been concluded that these shapes are due to administration causes, i.e. care trajectories are often closed when this is compulsory by the DBC systematic, and not when the actual care delivery process has been finished.
- The second finding also concerns MagnaView analysis and is part of the process patterns category, and regards the contrast between the 'number of activities per care trajectory' –view and the 'relative duration of care trajectories' –view. In particular the 'number of activities per care trajectory' –view shows the sequence of activities of the care trajectories without waiting times. The shape of the resulting curve is characterized by a negative exponential distribution, i.e. concave shaped. This indicates that relative many care delivery processes in GGzE Centre child and adolescent psychiatry contain only a few activities, and that for only a few client flows lots of activities have been registered. In contrast we have the 'relative duration of care trajectories' –view, in which waiting times between activities are present. Typically the shape of that curve is characterized by a belly distribution, i.e. spherical shaped. This remarkable finding has lead to additional analysis of the 'relative duration of care trajectories' –view, which strives to identify client groups.
- The most considerable finding from ProM concerns convenient arrangement when making use of log files containing more or less aggregated data. For example the process model containing all closed care trajectories in GGzE Centre child and adolescent psychiatry obtained by means of the heuristic miner plug-in is typically characterized by complexity and inconvenient arrangement, i.e. a spaghetti model. Typically, a more convenient arranged process model can be achieved by making use of aggregating the activities (or originators) to a higher level, for example a level 1 naming level. Moreover, ProM is also able to deal with unstructured processes by means of certain mining plug-ins. The method contains the fuzzy miner approach which uses a mixture of abstraction and clustering techniques.
- The most considerable finding concerning the identification of client groups is that, based on the mentioned indicators, indeed a distinction of client groups could be made. In particular, the client groups 'rapid discharge' and 'long-term no treatment' can be distinguished. The rapid discharge group accounts for 34% of the total care trajectories, and only for 4% of the total performed activities. The long-term no treatment, i.e. time between two successive activities $\geq$ 90 days, accounts for 30% of the total care trajectories, and for 26 % of the total performed activities.
- A second finding about the identification of client groups is that another interesting group can be distinguished. This is the group of client processes characterized by care trajectories with more than 5 activities and where the time between two successive activities is always smaller than 30 days. In particular, this group amounts only 9% of the total care trajectories, but accounts 38% of the total performed activities in the data set.
- A third finding from the identification of client groups is that by means of comparing the activity compounding and originator constellation within the client groups processes, it is found that the group with small waiting times between activities are characterized by a relative high number of 'verblijf' and 'dagbesteding' activities, whereas client groups with at least one high waiting time between activities are characterized by a relative high number of 'diagnostiek', 'behandeling', and 'algemene indirecte tijd' activities. For the 'rapid discharge' group relative a lot time is spend at 'diagnostiek' and 'algemene indirecte tijd' activities.

The most considerable notifications of the case study are:

- With regard to the dataset it should be noted that recent process improvement initiatives cannot be recovered from the data yet, because this concerns relative little cases and moreover these care trajectories are often not closed yet, i.e. clients are still present in the treatment processes.
- With regard to the application of ProM at DBC-GGZ data. This concerns the timestamp information present in DBC-GGZ data. Usually timestamps contain besides a date also a start and completion of an event by means of including the point in time (hours, minutes, eventually seconds). Since this information is not included in the DBC-GGZ timestamp no computations with regard to duration of activities, e.g. processing times, can be made; this obstructs the usability of quite a number of plug-ins in ProM.
- In MagnaView the waiting times has been calculated by means of the time difference between two activities. Although this is the only possible measure when DBC-GGZ data is concerned the indicator cause a deal of controversy because of two reasons. First, typically mental healthcare delivery deals with positive waiting times like discussed by Kujala et al. (2006). Second, this waiting time measure typically calculates the time between two successive events, however, it does not tell the difference between demand and delivery. If for example a specific diagnostic activity has been requested, but a client has been putted on a waiting list and in the mean time some other activities take place, the calculated measure does not give an accurate description of the actual waiting time.
- Another point of discussion concerns the choice for the process indicators used for clustering and filtering. Although auditors reacted positively on the presented results, it is recommended to take into consideration whether for example the ‘primary diagnosis' groups lead to sufficient accurate results for classifying care trajectories with regard to defining iso-process client groups. Furthermore the distinction clinical and ambulant should be made when classifying client groups. Moreover, one can wonder if classification at the care trajectory level is most appropriate, or that perhaps classification on a DBC level offers much more opportunity (e.g. by means of code lists) to identify iso-process patient groups.

In order to evaluate particular aspects of the data-based method for mental healthcare process analysis the following criteria set by Riemers (2009) where evaluated:

1. The results should be presented within limited time.
2. Process models should have a high fitness.
3. The approach should be positively evaluated by the medical specialists and managers.
4. The results should be simple to understand for the medical specialists and managers.
5. Interactive analysis should be possible.
6. The analysis should focus on certain aspects of the treatment process.

According to Joosten all criteria were met: "the presentations and discussions Cliëntstromen in GGzE Centrum Kinderen en Jeugdpsychiatry (client flows in GGzE Centre child and adolescent psychiatry)' serve as proof".

In particular there was concluded that the main advantages of data visualization are: (i) a better understanding about the process; and (ii) a better understanding about bottlenecks within the process. In addition, the results have a positive effect on managing processes at GGzE Centre in child and adolescent psychiatry, because: (i) managers and profession gained insight about what really happened in their processes by means of analyses of data they registered themselves; and (ii) these insights support the desire for structural process improvement and better registration of what really occurred during care delivery processes. For GGzE Centre research and development in particular, the data-based method is of relevance, because: (i) it enables researchers to logically aggregate process data and obtain purposeful process analyses, and (ii) based on these analyses, care delivery processes could be better controlled, which serves as starting point for future process improvement.

Although, in general it could be stated that both the case results as well as the method are evaluated positively, there are still some points of discussion concerning the research questions. The first point of discussion is that the part of the the research question, "at a level that client flows can be identified and design solutions for logistical improvement can be developed" has not totally achieved. To a large extend it succeed to identify client groups; however more detailed divisions and analyses with regard to activity compounding and originator constellation within the client groups processes is desired. Therefore more iteration in the method could be passed through. Eventually, other more advanced clustering techniques could be used to identify client groups based on their characteristics. In any case clear indicators for process identification should be defined on forehand; one should know where to look for.

With regard to "developing design solutions for logistical improvement" there should be concluded that this stage is not yet reached. Although a good start has been made it is not yet possible to improve the processes. According to Vissers (2006) five steps should be completed in order to complete a process improvement project. These are: (1) identification of iso-process patient groups, for which a specific organization of services is developed; (2) description of these processes in a way that allows analysis of the service and resource use impacts of processes; (3) definition of a production control per patient group, taking into account the characteristics of the process considered; (4) setting objectives for the performance of the process to enable its monitoring; and (5) taking the responsibility for process management in order to make improvements process sustainability. When evaluating the case results it can be concluded that a good attempt with regard to the first and second step has been taken. However, steps three, four, and five still needs to be done in order to improve care delivery processes at GGzE Centre child and adolescent psychiatry.

Furthermore, it is recommended to managers of GGzE to pay attention at the requirements of healthcare processes with regard to the focused factory approach, which are:

- With a predictable process, after the specification, and after a treatment plan is set up;
- With a low variety in the delivery processes;
- With common requirements in quality and service;
- That are homogenous in resource requirements;
- That do not require high flexibility.

When one can manage to identify (parts of) process with these characteristics, it is expected that the focused factory concept is at least partially applicable in healthcare organizations:

- To a part of the total service chain, between well-defined decoupling points;
- To specific aspects, such as service, of the total set of requirements to be met;
- Processes should be transparent and defined in such a way that they can be analyzed in terms of their homogeneity.

6 References

Aalst, W.M.P. van der, Netjes, M., & Reijers, H.A. (2007a). *Chapter 4: Supporting the Full BPM Life-Cycle Using Process Mining and Intelligent Redesign.* In: Siau, K., editor, Contemporary Issues in Database Design and Information Systems Development, pp. 100-132. IGI Global, Hershey, USA.

Aalst, W.M.P. van der, Reijers, H.A., Weijters, A.J.M.M., Dongen, B.F. van, Alves de Medeiros, A.K, Song, M., & Verbeek, H.M.W. (2007b). Business process mining: An industrial application. *Information Systems , 32, 713-732.*

Alves de Medeiros, A.K., & Weijters, A.J.M.M. (2009). *ProM Framework Tutorial v3*. Website: process mining http://prom.win.tue.nl/research/wiki/prom/tutorials.

Bertrand, J.W.M., & Vries, G. de. *Lessons to be learned from OM*. In: Vissers, J.H.M., & Beech, R. Health operations management: patient flow logistics in health care. (2005). Routledge Taylor & Francis Group, Abingdon.

Bokkem, S. van, & Velde, V. van der. (2003). *Handboek Met zorg besluiten – Indicatiestelling voor behandeling in de GGz.*

Bruys, M., Stikkelorum, M., & Ommerborn, G. (2008). *Standaard voor DIS Gegevensaanlevering DBC door GGZ zorgaanbieders*. Referentie: DIS00478 DIS GGZ Gegevensaanlevering DBC 4.0 v4.0 definitief.doc. van website: http://www.dbconderhoud.nl/

DBC-Begrippenlijst voor de GGZ Versie 1.0. V20080730. van website: http://www.dbconderhoud.nl/

Dongen, B.F., van, Alves de Medeiros, A.K., Verbeek, H.M.W., Weijters, A.J.M.M., & Aalst, W.M.P. van der. (2005). *The ProM framework: A new era in process mining tool support*, 26th International Conference on Applications and Theory of Petri Nets (ICATPN 2005), G. Ciardo and P. Darondeau, LNCS 3536, pages 444-454.

Geestelijk Gezondheidszorg Eindhoven en de Kempen. Website: http://www.ggze.nl/ (September 25, 2009).

Günther, C.W., & Aalst, W.M.P. van der. (2007). *Fuzzy mining – Adaptive Process Simplification Based on Multi-perspective Metrics*. In: G.Alonso, P. Dadam, M. Rosemann (Eds.): BPM 2007, LNCS 4717, pp. 328-343, 2007. Springer-Verlag Berlin Heidelberg.

Hall, R.W. (Editor). (2006). *Patient Flow: Reducing delay in healthcare delivery*. Springer Science + Business Media, LLC, New York.

Hilderink, I., Vink, M., Land, H. van 't, & Fotiadis, L. (2008). *Trendrapportage GGZ 2008: Deel 3 Kwaliteit en Effectiviteit.* Trimbos instituut, Netherlands Institute of Mental Health and Addiction.

Hoof, F. van, Fotiadis, L., Vijselaar, J., & Hasker, J. (2008). *Trendrapportage GGZ 2008: Deel 1 Organisatie, structuur en financiering - basisanalyse*. Trimbos instituut, Netherlands Institute of Mental Health and Addiction.

Hopp, W.J., & Spearman, M.L. (2000). *Factory Physics: Foundations of Manufacturing Systems*. 2nd edition. Irwin McGraw-Hill, New York.

Institute for Healthcare Improvement website: http://www.ihi.org/ihi (October 2, 2009).
Jonker, J., & Pennink, B.J.W. (2000). *De kern van methodologie – Een inleiding*, Van Gorcum, Assen.

Joosten, T.C.M. (2009). *Startbijeenkomst: verbeteren zorglogistiek. GGzE Centrum Kinderen en jeugdpsychiatry*. 22 september 2009.

Joosten, T., Bongers, I., & Janssen, R. (2009). Application of lean thinking to health care: issues and observations. *International Journal for Quality in Health Care*, ?, ?.

Joosten, T., Bongers, I., & Meijboom, B. (2008). Care programmes and integrated care pathways. *International Journal of Health Care Quality Assurance, 21 (5), 472-486.*

Keen, J., Moore, J., & West, R. (2006). Pathways, networks and choice in health care. *International Journal of Health Care Quality Assurance, 19 (4), 316-327.*

Kujala, J., Lillrank, P., Kronström, V., & Peltokorpi, A. (2006). Time-based management of patient processes. *Journal of Health Organization and Management, 20 (6), 512-524.*

Land, H. van 't, Grolleman, J., Mutsaers, K., & Smits, C. (2008). *Trendrapportage GGZ 2008: Deel 2 Toegang en Zorggebruik - basisanalyse*. Trimbos instituut, Netherlands Institute of Mental Health and Addiction.

Linskens, N.S.J. (2009). *Process analysis and improvements at GGzE*. Master of Science graduation project. Maastricht University, Faculty of Health, Medicine, and Life Science.

MagnaView website: http://www.magnaview.nl/ (11 May, 2010).

MagnaView B.V. (2009). *MagnaView Explorer and Designer Manual*.

Mans, R.S., (?), msaccessdatabasetutorial_v2. ProM website: http://prom.win.tue.nl/research/wiki/promimport/tutorials

Mans, R.S., Schonenberg M.H., Song, M., Aalst, W.M.P. van der, & Bakker, P.J.M. (2008). Application of Process Mining in Healthcare – A Case Study in a Dutch Hospital. *Fred, A., Filipe, J., & Gaboa, H. (Eds.): BIOSTEC 2008, CCIS 25, 425-538.*

Oost, H., & Markenhof, A. (2002). *Een onderzoek voorbereiden*. HBuitgevers, Baarn. Eerste druk, achtste oplage 2006.

Porter, M.E., & Teisberg, E.O. (2004). Redefining Competition in Health Care. *Harvard Business Review, 82, 64-76.*

Process mining. Website Process Mining Group, Math&CS department, Eindhoven University of Technology. http://prom.win.tue.nl/research/wiki/ or www.processmining.org, 2009.

Riemers, P. (2009). *Process improvement in Healthcare: A data-based method using combination of process mining and visual analytics*. Master of Science graduation project. Eindhoven University of Technology.

Schouten, L., Minkman, M., Moel, J. de, & Everdingen, J. van. (2007). *Doorbreken met resultaten in de gezondheidszorg*. Van Gorcum, Assen.

Sogeler, D. (2006). *Analysis and Improvement of Data Handling Performance of a Visualization Tool*. Master of Science graduation project. Eindhoven University of Technology.

Spelregels DBC-registratie Versie 2009 F1.0. website: www.dbcggz.nl

Thomas, J.J., & Cook, K.A. (2006). Visualization Viewpoints: A visual Analytics Agenda. *IEEE Computer Graphics and Applications, Jan/Feb 2006, 10-13*.

Torres Ramos, L. (2009). *Healthcare Process Analysis: validation and improvements of a data-bases method using process mining and visual analytics*. Master of Science graduation project. Eindhoven University of Technology.

Versnelling in de Jeugd-GGZ website: http://www.versnellingjeugdggz.nl/ (May 3, 2009).

Vissers, J.H.M. (2006). *A Logistics approach for hospital process improvements*. In: Hall, R.W. (Editor). (2006). Patient Flow: Reducing delay in healthcare delivery. Springer Science + Business Media, LLC, New York.

Vissers, J.H.M., Bertrand, J.W.M., & Vries, G. de. (2005). *Frameworks for health operations management.* In: Vissers, J.H.M., & Beech, R. Health operations management: patient flow logistics in health care. (2005). Routledge Taylor & Francis Group, Abingdon.

Vissers, J.H.M., & Beech, R. (2005). *Health operations management: patient flow logistics in health care*. Routledge Taylor & Francis Group, Abingdon.

Weijters, A.J.M.M., van der Aalst, W.M.P., Alves de Medeiros, A.K.. (2006). Process Mining with HeuristicsMiner Algorithm. *BETA Working Paper Series, WP 166*, Eindhoven University of Technology, Eindhoven.

Appendix A: Research methodology

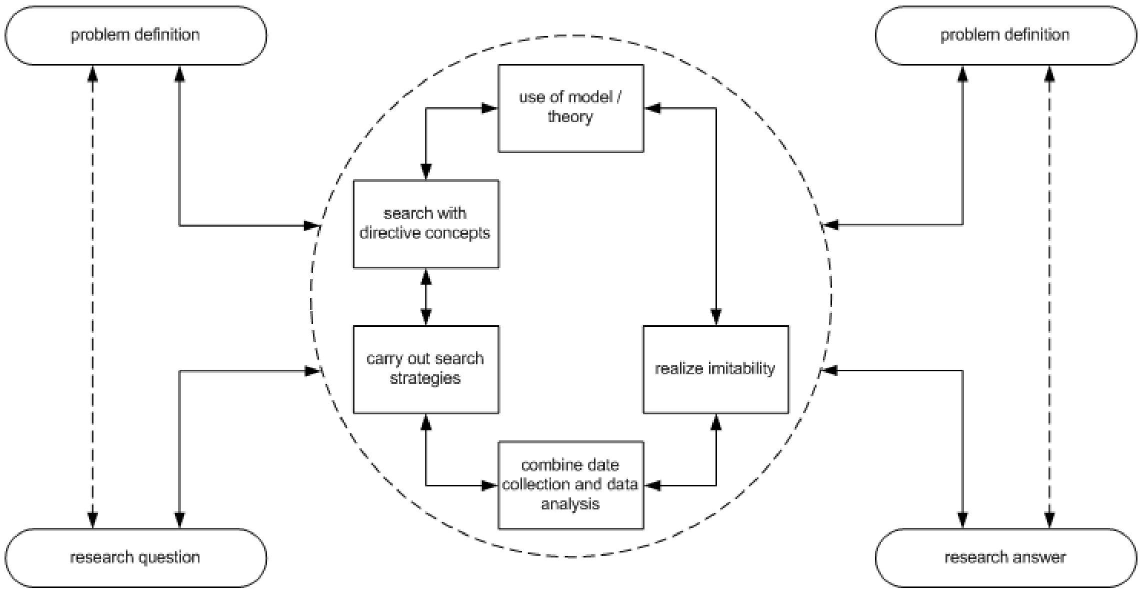


Figure 25 Qualitative research methodology (adapted from Jonker and Pennink, 2000)

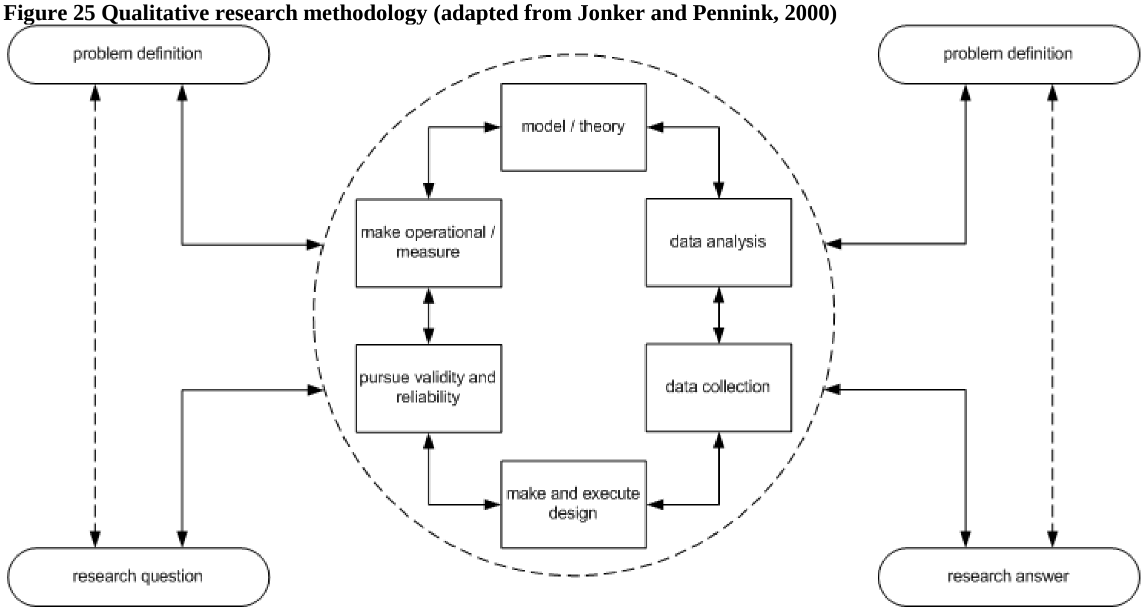
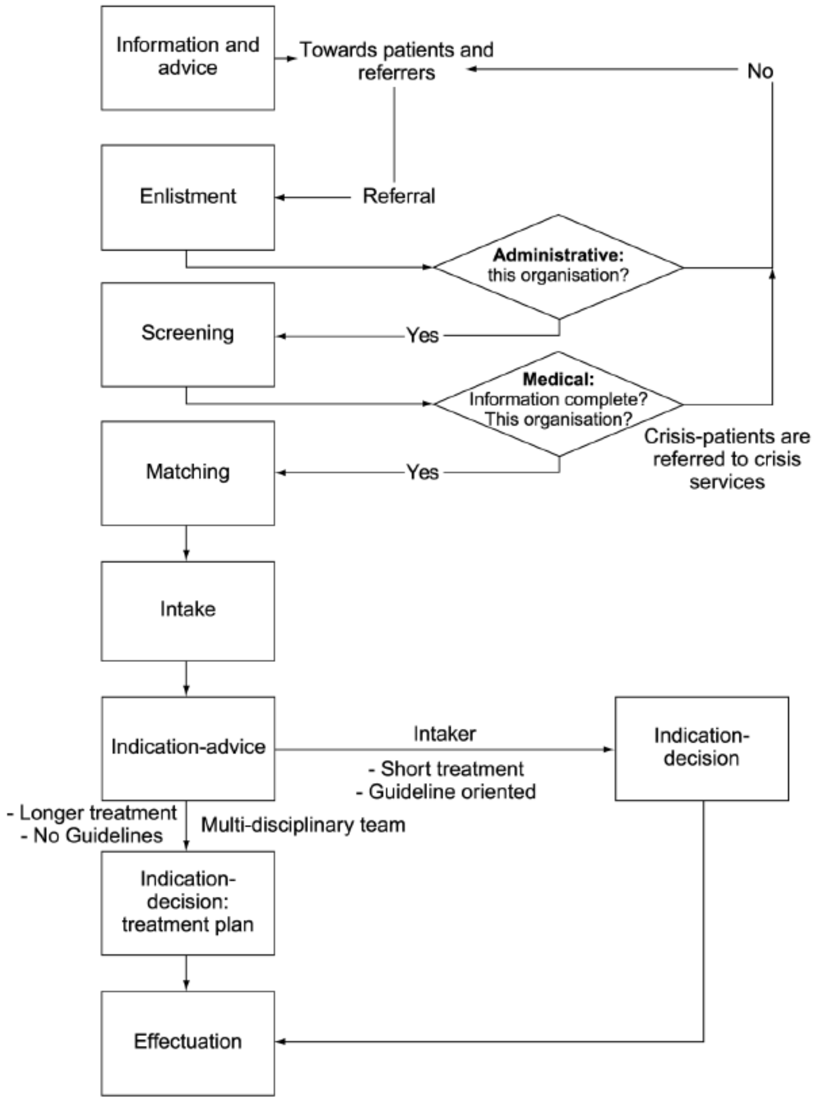


Figure 26 Quantitative research methodology (adapted from Jonker and Pennink, 2000)

Appendix B: Care programming in GGzE



Source: Derived from van Bokkem *et al.* (2003)

Figure 27 Admission process steps in GGzE CPs (adapted from Joosten et al., 2008)

Appendix C: Conceptual production control framework for health OM

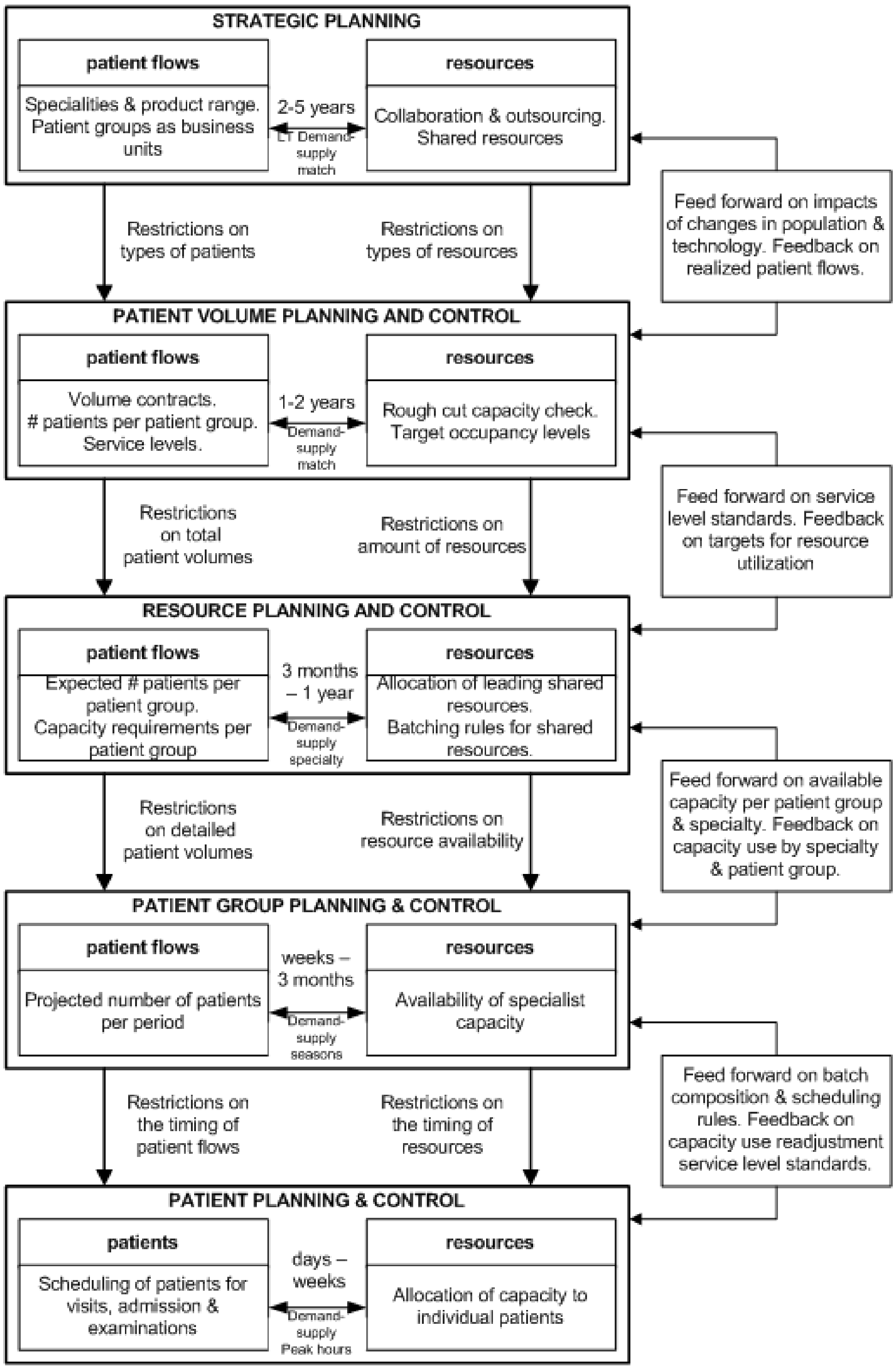


Figure 28 Conceptual framework of health OM planning and control processes (adapted from Vissers, 2006)

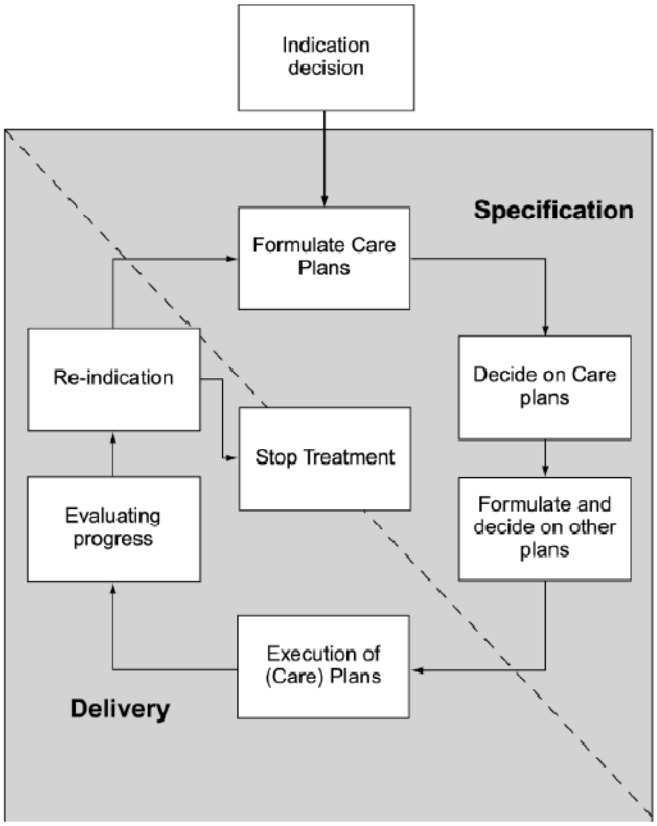


Figure 29 Treatment cycle in GGzE CPs (adapted from Joosten et al., 2008)

Appendix D: Example code list

CL_ACTIVITEIT

Code	Data Type	Beschrijving
CL_ACTIVITEIT_BEGINDATUM	numeric(8)	Datum begin geldigheid in notatievorm EEJJMMDD
CL_ACTIVITEIT_EINDDATUM	numeric(8)	Datum eind geldigheid in notatievorm EEJJMMDD
CL_ACTIVITEIT_CODE	varchar(20)	Unieke code voor de activiteit.
CL_ACTIVITEIT_GROEPCODE	varchar(20)	Code voor groep waar deze code toe behoort.
CL_ACTIVITEIT_ELEMENT	nvarchar(255)	Beschrijving van de code (sub niveau).
CL_ACTIVITEIT_BESCHRIJVING	nvarchar(255)	Uitgebreide beschrijving van de activiteiten code.
CL_ACTIVITEIT_HIERARCHIENIVEAU	int	Hiërarchisch niveau van de activiteit. (0 minst gespecificeerd).
CL_ACTIVITEIT_SELECTEERBAAR	int	0 - niet selecteerbaar. 1 - wel selecteerbaar, diepste niveau. 2 - wel selecteerbaar, maar ook dieper selecteerbaar niveau mogelijk.
CL_ACTIVITEIT_SORTEERVOLGORDE	int	Sorteervolgorde van de activiteiten tbv rangschikking.
CL_ACTIVITEIT_SYSID	int	Systeem eigen sleutel voor de activiteiten code.
CL_ACTIVITEIT_SOORT	varchar(20)	Tijdschrijven, Verblijfsdag, Dagbesteding of Verrichting
CL_ACTIVITEIT_MAG_DIRECT	char(1)	Betreft een activiteit waarop wel of niet directe tijd mag worden geschreven. J: mag wel directe tijd worden geschreven voor de activiteit. N: mag geen directe tijd worden geschreven voor activiteit
CL_ACTIVITEIT_MAG_INDIRECT	char(1)	Betreft een activiteit waarop wel of niet algemeen indirecte (algemene) tijd mag worden geschreven. J: mag wel indirecte tijd worden geschreven voor

http://www.nza.nl/binaries/7113/12291/100.047-bijlage.pdf

Appendix E: ProM MXML format

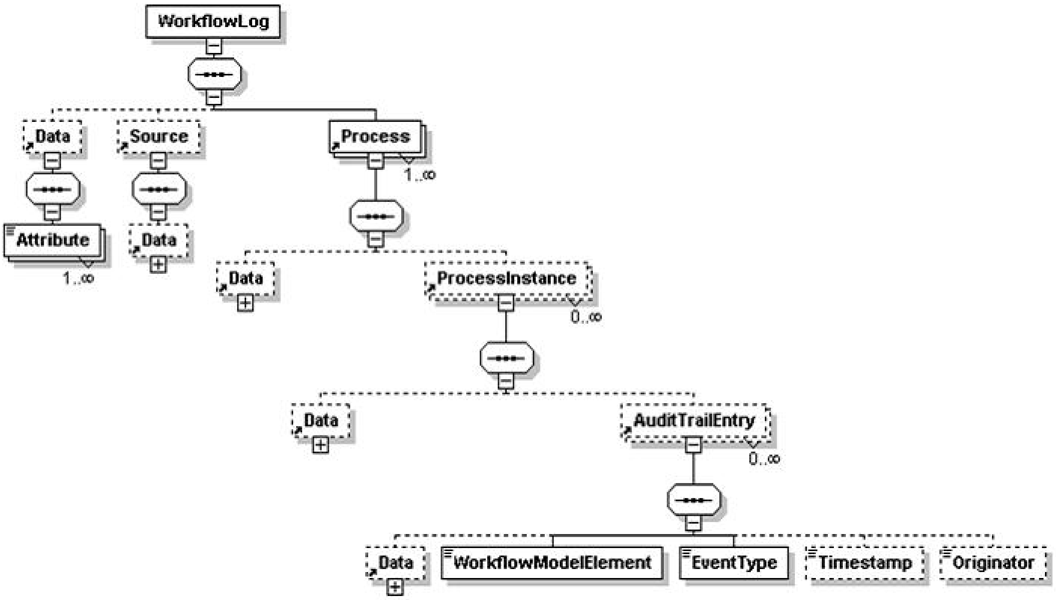


Figure 30 MXML format (adapted from van Dongen et al., 2005)

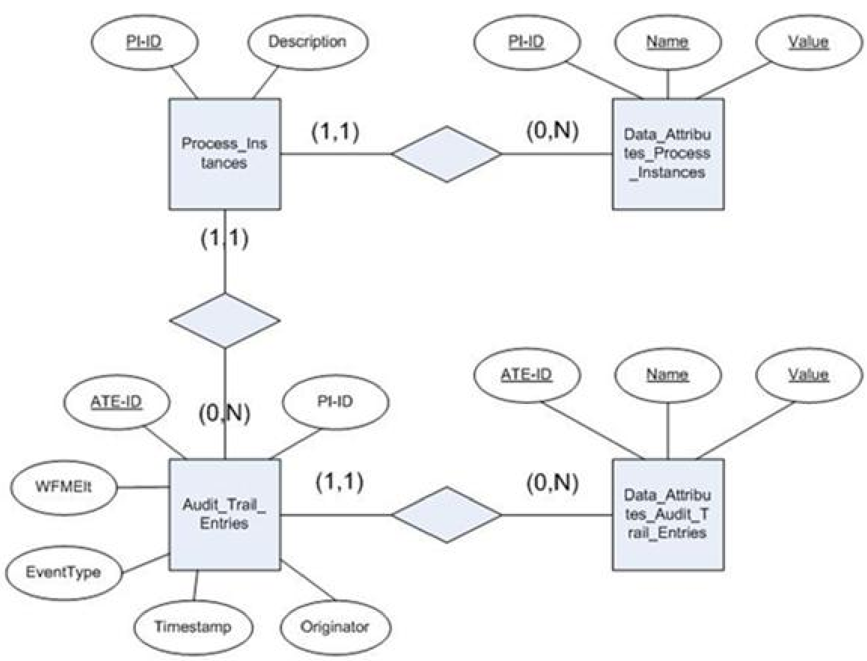


Figure 31 Entity Relation diagram for the four Process Mining tables (adapted from Mans, ?)

Appendix F: Data attributes MagnaView

Field name	*Data Type*	*Data source*	*Table*	*Application*
Activity identification number	Text	DBC database	Timekeeping; day spending; days of stay	**KEY**
Activity code	Text	DBC database	Timekeeping; day spending; days of stay	**activity_id, *filter activity***
Activity code_level 1	Text	-	-	**candidate activity_id, *candidate filter***
Activity name_level 1	Text	-	-	detailed description
Activity code_level 2	Text	-	-	**candidate activity_id, *candidate filter***
Activity name_level 2	Text	-	-	detailed description
Activity code_level 3	Text	-	-	**candidate activity_id, *candidate filter***
Activity name_level 3	Text	-	-	detailed description
EventType	Text	"start"	-	**Eventtype**
Timestamp treatment	Date/Time	DBC database	Timekeeping; day spending; days of stay	**Timestamp**
Direct client bounded time	Number	DBC database	Timekeeping	**processing time direct**
Indirect client bounded time_travel	Number	DBC database	Timekeeping	**processing time indirect**
Indirect client bounded time_general	Number	DBC database	Timekeeping	**processing time indirect**
Number	Number	DBC database	Day spending; days of stay	**number**
CL_activiteit_groepcode	Text	GGZ Codelijsten	CL_ACTIVITEIT2009	formal activity code level
CL_activiteit_element	Text	GGZ Codelijsten	CL_ACTIVITEIT2009	formal activity description
CL_activiteit_beschrijving	Text	GGZ Codelijsten	CL_ACTIVITEIT2009	formal activity description
CL_activiteit_soort	Text	GGZ Codelijsten	CL_ACTIVITEIT2009	formal activity description
Profession code	Text	DBC database	Timekeeping	**employee_id, *filter employee***
Profession code_level 1	Text	-	-	**candidate employee_id, *candidate filter***
Profession name_level 1	Text	-	-	detailed description
Profession code_level 2	Text	-	-	**candidate employee_id, *candidate filter***
Profession name_level 2	Text	-	-	detailed description
Profession code_level 3	Text	-	-	**candidate employee_id, *candidate filter***
Profession name_level 3	Text	-	-	detailed description
CL_beroep_groepcode	Text	GGZ Codelijsten	CL_BEROEP2009	formal profession code level
CL_beroep_beschrijving	Text	GGZ Codelijsten	CL_BEROEP2009	formal profession description
DBC identification number	Text	DBC database	DBC trajectory	do not use
Care type code	Number	DBC database	DBC trajectory	***candidate filter care type***
CL_zorgtype_element	Text	GGZ Codelijsten	CL_ZORGTYPE2009	description care type
CL_zorgtype_beschrijving	Text	GGZ Codelijsten	CL_ZORGTYPE2009	description care type
Circuit code	Number	DBC database	DBC trajectory	***filter circuit***
CL_circuit_beschrijving	Text	GGZ Codelijsten	CL_CIRCUIT2009	description circuit
DBC product group code	Text	DBC database	DBC trajectory	do not use
CL_productgroep_omschrijving_verblijf	Text	GGZ Codelijsten	CL_PRODUCTGROEP2009	description product group
CL_productgroep_omschrijving_behandelin	Text	GGZ Codelijsten	CL_PRODUCTGROEP2009	description product group
CL_productgroep_beschrijving	Text	GGZ Codelijsten	CL_PRODUCTGROEP2009	description product group
CL_productgroep_setting	Text	GGZ Codelijsten	CL_PRODUCTGROEP2009	***filter setting***
CL_productgroep_categorie	Text	GGZ Codelijsten	CL_PRODUCTGROEP2009	description product group
Care trajectory identification number	Text	DBC database	Care trajectory	**class_id**
Primary diagnosis code	Text	DBC database	Care trajectory	formal diagnosis code
Primary diagnosis date	Date/Time	DBC database	Care trajectory	do not use
Care trajectory starting date	Date/Time	DBC database	Care trajectory	**CT starting date**
Care trajectory final date	Date/Time	DBC database	Care trajectory	**CT final date**
Reference number	Text	DBC database	CT; Patient	**object_id**
ZA date of birth	Date/Time	DBC database	Patient	***filter age***
ZA sex	Number	DBC database	Patient	***filter sex***
CL_diagnose_beschrijving	Text	GGZ Codelijsten	CL_DIAGNOSE2009	formal diagnosis description
CL_diagnose_groepcode	Text	GGZ Codelijsten	CL_DIAGNOSE2009	formal diagnosis description
CL_diagnose_element	Text	GGZ Codelijsten	CL_DIAGNOSE2009	formal diagnosis description
CL_diagnose_prestatiecode_naamgeving	Text	GGZ Codelijsten	CL_DIAGNOSE2009	***filter diagnosis***

Color legend

Red = Activity related
Blue = Profession related
Green = Care trajectory (or DBC) related
Yellow = Client related

Appendix G: Coding activities and employees

Activities and operations

Activiteiten en verrichtingen

Versie 2009, F1.0

Tijdsregistratie behandelaars: Direct patiëntgebonden tijd; Indirect patiëntgebonden tijd, (voorbereiden activiteit, verslaglegging ivm activiteit); Indirecte tijd, reistijd

Registratie door administratie: Eenheden / aantallen

[ ] = Invoer tijdsregistratie

[ ] = Invoer aantallen / eenheden

Code				Activiteit	Direct patiëntgebonden tijd	Indirect patiëntgebonden tijd, (voorbereiden activiteit, verslaglegging ivm activiteit)	Indirecte tijd, reistijd	Eenheden / aantallen
1				**Pré Intake**				
2				**Diagnostiek**				
	1			Intake en screening				
	2			Verwerven informatie van eerdere behandelaars				
	3			Anamnese / vragenlijsten				
	4			Hetero anamnese				
	5			Psychiatrisch onderzoek				
	6			Psychodiagnostisch onderzoek				
		1		Intelligentie				
		2		Neuropsychologisch				
		3		Persoonlijkheid				
	7			Orthodidactisch onderzoek				
	8			Vaktherapeutisch onderzoek				
	9			Contextueel onderzoek (gezin, school, etc)				
	10			Lichamelijk onderzoek				
	11			Aanvullend onderzoek (lab, rad, klin.neur.fys, nucl.gen.)				
	12			Advisering				
	13			Overige diagnostische activiteiten				
3				**Behandeling**				
	1			**Communicatieve behandeling**				
		1		**Follow up behandelcontact**				
			1	patiënt individueel				
			2	patiënt in groep				
			3	systeem (gezin/paar/ouders) met patiënt				
			4	systeem (gezin/paar/ouders) zonder patiënt individueel				
			5	systeem (gezin/paar/ouders) zonder patiënt in groep				
		2		**Steunend en structurerend behandelcontact**				
			1	patiënt individueel				
			2	patiënt in groep				
			3	systeem (gezin/paar/ouders) met patiënt				
			4	systeem (gezin/paar/ouders) zonder patiënt individueel				
			5	systeem (gezin/paar/ouders) zonder patiënt in groep				
		3		**Psychotherapie**				
			1	Psychoanalyse				
			1.1	patiënt individueel				
			1.2	patiënt in groep				
			1.3	systeem (gezin/paar/ouders) met patiënt				
			1.4	systeem (gezin/paar/ouders) zonder patiënt individueel				
			1.5	systeem (gezin/paar/ouders) zonder patiënt in groep				
			2	Psychodynamische psychotherapie				
			2.1	patiënt individueel				
			2.2	patiënt in groep				
			2.3	systeem (gezin/paar/ouders) met patiënt				
			2.4	systeem (gezin/paar/ouders) zonder patiënt individueel				
			2.5	systeem (gezin/paar/ouders) zonder patiënt in groep				
			3	Gedragstherapie				
			3.1	patiënt individueel				
			3.2	patiënt in groep				
			3.3	systeem (gezin/paar/ouders) met patiënt				
			3.4	systeem (gezin/paar/ouders) zonder patiënt individueel				
			3.5	systeem (gezin/paar/ouders) zonder patiënt in groep				

		4		Cognitieve gedragstherapie			
			1	patiënt individueel			
			2	patiënt in groep			
			3	systeem (gezin/paar/ouders) met patiënt			
			4	systeem (gezin/paar/ouders) zonder patiënt individueel			
			5	systeem (gezin/paar/ouders) zonder patiënt in groep			
		5		Interpersoonlijke therapie			
			1	patiënt individueel			
			2	patiënt in groep			
			3	systeem (gezin/paar/ouders) met patiënt			
			4	systeem (gezin/paar/ouders) zonder patiënt individueel			
			5	systeem (gezin/paar/ouders) zonder patiënt in groep			
		6		Cliënt gerichte therapie			
			1	patiënt individueel			
			2	patiënt in groep			
			3	systeem (gezin/paar/ouders) met patiënt			
			4	systeem (gezin/paar/ouders) zonder patiënt individueel			
			5	systeem (gezin/paar/ouders) zonder patiënt in groep			
		7		Systeemtherapie			
			1	patiënt individueel			
			2	patiënt in groep			
			3	systeem (gezin/paar/ouders) met patiënt			
			4	systeem (gezin/paar/ouders) zonder patiënt individueel			
			5	systeem (gezin/paar/ouders) zonder patiënt in groep			
		8		Overig psychotherapie			
			1	patiënt individueel			
			2	patiënt in groep			
			3	systeem (gezin/paar/ouders) met patiënt			
			4	systeem (gezin/paar/ouders) zonder patiënt individueel			
			5	systeem (gezin/paar/ouders) zonder patiënt in groep			
	4			**Overige (communicatieve) behandeling**			
		1		patiënt individueel			
		2		patiënt in groep			
		3		systeem (gezin/paar/ouders) met patiënt			
		4		systeem (gezin/paar/ouders) zonder patiënt individueel			
		5		systeem (gezin/paar/ouders) zonder patiënt in groep			
2				**Farmacotherapie**			
3				**Fysische therapie**			
	1			Elektroconvulsietherapie			
	2			Lichttherapie			
	3			Transcraniële magnetische stimulatie			
	4			Overig behandeling fysische technieken			
4				**Vaktherapie**			
	1			Creatieve therapie (drama, beeldend, muziek, dans, tuin, etc)			
		1		patiënt individueel			
		2		patiënt in groep			
		3		systeem (gezin/paar/ouders) met patiënt			
		4		systeem (gezin/paar/ouders) zonder patiënt individueel			
		5		systeem (gezin/paar/ouders) zonder patiënt in groep			
	2			Psychomotorische therapie (beweging, expressie, interactie)			
		1		patiënt individueel			
		2		patiënt in groep			
		3		systeem (gezin/paar/ouders) met patiënt			
		4		systeem (gezin/paar/ouders) zonder patiënt individueel			
		5		systeem (gezin/paar/ouders) zonder patiënt in groep			
	3			Vaktherapie overig			
		1		patiënt individueel			
		2		patiënt in groep			
		3		systeem (gezin/paar/ouders) met patiënt			
		4		systeem (gezin/paar/ouders) zonder patiënt individueel			
		5		systeem (gezin/paar/ouders) zonder patiënt in groep			

	5		**Fysiotherapie**				
		1	patiënt individueel				
		2	patiënt in groep				
		3	systeem (gezin/paar/ouders) met patiënt				
	6		**Ergotherapie**				
		1	patiënt individueel				
		2	patiënt in groep				
		3	systeem (gezin/paar/ouders) met patiënt				
4			**Begeleiding**				
	1		**Activerend begeleidingscontact**				
		1	patiënt individueel				
		2	patiënt in groep				
		3	systeem (gezin/paar/ouders) met patiënt				
		4	systeem (gezin/paar/ouders) zonder patiënt individueel				
		5	systeem (gezin/paar/ouders) zonder patiënt in groep				
	2		**Ondersteunend begeleidingscontact**				
		1	patiënt individueel				
		2	patiënt in groep				
		3	systeem (gezin/paar/ouders) met patiënt				
		4	systeem (gezin/paar/ouders) zonder patiënt individueel				
		5	systeem (gezin/paar/ouders) zonder patiënt in groep				
5			**Verpleging**				
	1		Verpleging				
6			**Crisisopvang**				
	1		Crisiscontact binnen kantooruren				
	2		Crisiscontact buiten kantooruren				
7			**Algemeen indirecte tijd**				
	1		Zorgcoördinatie				
	2		No show				
	3		Interne patiëntbespreking (MDO)				
	4		Extern overleg met derden (buiten de instelling)				
	5		Verslaglegging algemeen (b.v. ontslagbrief, correspondentie)				
	6		Activiteiten ivm juridische procedures (b.v. IBS, BOPZ)				
	7		Regelen tolken				
8			**Verblijf (per verblijfsdag)**				
	1		Verblijf kinderen en jeugdigen				
			1-6: Verblijf kinderen en jeugdigen 1, 2, 3, 4, 5, 6*				aantal verblijfsdagen
	2		Verblijf ouderen				
			1-6: Verblijf ouderen 1, 2, 3, 4, 5, 6*				aantal verblijfsdagen
	3		Verblijf volwassenen kort				
			1-6: Verblijf volwassenen kort 1, 2, 3, 4, 5, 6*				aantal verblijfsdagen
	4		Verblijf verslavingszorg				
			1-6: Verblijf verslavingszorg 1, 2, 3, 4, 5, 6*				aantal verblijfsdagen
	5		Verblijf forensisch				
			1-6: Verblijf forensisch 1, 2, 3, 4, 5, 6*				aantal verblijfsdagen
	6		Verblijf volwassenen lang				
			1-6: Verblijf volwassenen lang 1, 2, 3, 4, 5, 6*				aantal verblijfsdagen
9			**Dagbesteding (per uur)**				
	1		Dagbesteding sociaal (ontmoeting)				aantal uren
	2		Dagbesteding activering (dagactiviteiten)				aantal uren
	3		Dagbesteding educatie				aantal uren
	4		Dagbesteding arbeidsmatig				aantal uren
	5		Dagbesteding overig				aantal uren
10			**Verrichting**				
	1		Electroconvulsietherapie				aantal behandelingen
	2		Methadon (ambulante verstrekking per maand)				verstrekking per maand

* verblijfsdag categorie 6 is gereserveerd voor de registratie van verblijfsdagen zonder overmachting

Employees

FUNCTIE CODE	KORTE FUNCTIE BESCHRIJVING	UITGEBREIDE FUNCTIE BESCHRIJVING
MB	**Medische beroepen**	**Medische beroepen**
MB.BG	Basisberoep Gezondheidszorg (BG)	Basisberoep Gezondheidszorg (BG)
MB.BG.basis	MB - Arts	Arts (waaronder Agio/Agnio)
MB.SF	Specialisatie / functiedifferentiatie (SF)	Specialisatie / functiedifferentiatie (SF)
MB.SF.vslarts	MB - Arts versl	Arts verslavingszorg
MB.SF.sger	MB - Soc.geriater	Sociaal geriater
MB.SF.overig	MB - SF overig	Overig medisch SF
MB.SP	Specialisme (SP)	Specialisme (SP)
MB.SP.psych	MB - Psychiater	Psychiater
PT	**Psychotherapeutische beroepen**	**Psychotherapeutische beroepen**
PT.BG	Basisberoep Gezondheidszorg (BG)	Basisberoep Gezondheidszorg (BG)
PT.BG.psth	PT - Psychoth	Psychotherapeut
AG	**Agogische beroepen**	**Agogische beroepen**
AG.BI	Basisberoep initieel (BI)	Basisberoep initieel (BI)
AG.BI.mwd	AG - MWD	Maatschappelijk werkende (MWD)
AG.BI.sph	AG - SPH	Sociaal Pedagogisch Hulpverlener (SPH)
AG.BG	Basisberoep Gezondheidszorg (BG)	Basisberoep Gezondheidszorg (BG)
AG.BG.agoog	AG - Agoog	GGZ-agoog
AG.SF	Specialisatie / functiedifferentiatie (SF)	Specialisatie / functiedifferentiatie (SF)
AG.SF.vrstgeh	AG - verst.gehand.	Agoog verstandelijk gehandicapten
AG.SF.kjpsych	AG kj.psychiatrie	Agoog K&J psychiatrie
AG.SF.overig	AG - SF overig	Overig Agogisch SF
PB	**Psychologische beroepen**	**Psychologische beroepen**
PB.BI	Basisberoep initieel (BI)	Basisberoep initieel (BI)
PB.BI.ped	PB - Pedagoog	Pedagoog (waaronder orthopedagoog)
PB.BI.gzkd	PB - Gezondheidskundige	GGZ gezondheidskundige
PB.BI.psy	PB - Psycholoog	Psycholoog (geen verdere specialisatie)
PB.BG	Basisberoep Gezondheidszorg (BG)	Basisberoep Gezondheidszorg (BG)
PB.BG.gzpsy	PB - GZpsycholoog	GZ-psycholoog
PB.SF	Specialisatie / functiedifferentiatie (SF)	Specialisatie / functiedifferentiatie (SF)
PB.SF.gedrth	PB - gedragsth	Gedragstherapeut
PB.SF.kjth	PB - kj.therap	K&J-therapeut
PB.SF.overig	PB - SF overig	Overig psychologisch SF
PB.SP	Specialisme (SP)	Specialisme (SP)
PB.SP.klinps	PB - klinpsych	Klinisch psycholoog
VK	**Vaktherapeutische beroepen**	**Vaktherapeutische beroepen**
VK.BI	Basisberoep initieel (BI)	Basisberoep initieel (BI)
VK.BI.pmt	VK - PMT	Vaktherapeut psychomotorisch (PMT)
VK.BI.ct	VK - CT	Vaktherapeut creatief (CT)
VK.BG	Basisberoep Gezondheidszorg (BG)	Basisberoep Gezondheidszorg (BG)
VK.BG.vakth	VK - GZ vakth	GZ- vaktherapeut
VK.SF	Specialisatie / functiedifferentiatie (SF)	Specialisatie / functiedifferentiatie (SF)
VK.SF.vakth	VK - GGZ vakth	GGZ-vaktherapeut
VK.SF.overig	VK - SF overig	Overig vaktherapeutisch SF
VB	**Verpleegkundige beroepen**	**Verpleegkundige beroepen**
VB.BG	Basisberoep Gezondheidszorg (BG)	Basisberoep Gezondheidszorg (BG)
VB.BG.vrplk	VB - verplk	Verpleegkundige (art.3)
VB.SF	Specialisatie / functiedifferentiatie (SF)	Specialisatie / functiedifferentiatie (SF)
VB.SF.spv	VB - SPV	Sociaal Psych. Verpleegkundige (SPV)
VB.SF.cpv	VB - CPV	Consultatief Psych. Verpleegkundige (CPV)
VB.SF.fpv	VB - FPV	Forensisch Psychiatrisch Verpleegkundige (FPV)
VB.SF.overig	VB - SF overig	Overig verpleegkundig SF
VB.SP	Specialisme (SP)	Specialisme (SP)
VB.SP.vrplsp	VB - verplk.spec.	GGZ Verpleegkundige Specialist
OV	**Somatische beroepen (wet BIG)**	**Somatische beroepen (wet BIG)**
OV.BG	Basisberoep Gezondheidszorg (BG)	Basisberoep Gezondheidszorg (BG)
OV.BG.fysio	OV - Fysioth	Fysiotherapeut
OV.BG.ergo	OV - Ergoth	Ergotherapeut
OV.BG.diet	OV - Dietist	Dietist
OV.BG.logo	OV - Logopedist	Logopedist
OV.SP	Specialisme (SP)	Specialisme (SP)
OV.SP.neur	OV - Neuroloog	Neuroloog
OV.SP.harts	OV - Huisarts	Huisarts
OV.SP.karts	OV - Kinderarts	Kinderarts
OV.SP.kger	OV - Klin.geriater	Klinisch geriater
OV.SP.artsmg	OV - Arts maatsch.gzh	Arts maatschappij en gezondheid

Appendix H: Views available in MagnaView PAS-GGzE project

1. Analyses	
2. Organizational Analysis	
	1. Job description (employees)
	2. Job description (roles)
	3. Latent skills
	4. # care trajectories per diagnosis
3. Overview activities	
	1. Activities occurence
	2. Activity occurence per primary diagnosis
	3. First activities_primary diagnosis
	4. First activities_care trajectory
	5. First activiities_care trajectory
	6. First activities_primary diagnosis prestatiecode
	7. Last activities_primary diagnosis
	8. Last activities_care trajectory
	9. Last activities_primary diagnosis prestatiecode
	10. Last activities_care trajectory
4. Patterns	
	1. Dotted chart - actual time
	2. Dotted chart - relative time
	3. Dotted chart - logical
	4. Dotted chart - concurrency matrix
	5. Patterns - sequential
	6. Patterns per diagnosis - sequential
	7. Patterns - multi-set
	8. Patterns - lead time
5. Dependencies activities	
	1. Previous activities
	2. Next activities
6. Important activities	
7. Bottlenecks - Activities	
	1. Waiting times
	2. Top 10 highest waiting times
	3. Processing times
	4. Top 10 highest processing times
	5. High standard deviation - processing times
8. Bottlenecks - Activities - Causes high processing times	
	1. Slow employees
	2. Slow employees that completed the activity
	3. Outliers processing times
	4. Number of times performed (emp completed act)
	5. Number of previous activities
	6. Processing times after previous activities
	7. Processing times compared to WIP
9. Bottlenecks - Activities - Causes high waiting times	
	1. Outliers waiting time
	2. Slow employees (1)
	3. Slow employees completed activity (1)
	4. Number of times performed
	5. Number of previous activities (1)
	6. Waiting time after previous activity
	7. Waiting time compared to WIP
10. Bottlenecks - Employees	
	1. Processing times
	2. Total direct client bounded time per profession
	3. Total direct client bounded time per profession per year
	4. Total indirect client bounded time per profession
	5. Total indirect client bounded time per profession per year
	6. Total client bounded time per profession
	7. Total client bounded time per profession per year
	8. High standard deviation processing times
	9. Top 10 highest processing times
	10. Top 10 highest processing times
	11. High standard deviation processing times
	12. Waiting times
	13. Top 10 highest waiting times
	14. High standard deviation waiting time
11. Bottlenecks - Employees - Causes high processing time	
	1. Outliers processing times
	2. Difficult activities
	3. Processing times after previous activities
12. Bottlenecks - Employees - Causes high waiting time	
	1. Outliers waiting time
	2. Type of activities
	3. Waiting time after previous activities
	4. Work in Process (1)
13. Bottlenecks - Cases	
	1. Lead time per case (closed only)
	2. Waitingtime per case
	3. Waitingtime W1
	4. Waitingtime per case
	5. Rework
	6. Waitingtime kiesbeter.nl
	7. Total client bounded time per care trajectory
14. Bottlenecks - Cases - Rework	
15. Bottlenecks - Work in Process	
	1. Work in Process (per week of year)
	2. Patients entered GGZ per week
	3. Activities in Process (per week of year)
16. Employees	
	1. Processed cases
	2. Top 10 employees processed most cases
	3. Top 10 employees processed least cases
	4. Activities performed
	5. Top 10 employees processed most activities
	6. Top 10 employees processed least activities
17. < No group name>	
	1. Case specific view
	2. Activity specific view

Appendix I: ProM analyses

Heuristic model

- Closed care trajectories only
- Activities level 1 and professions level 1
- Activities executed by more than 1 resource are grouped and resources are renamed as "multiple_*name level1 activity*"

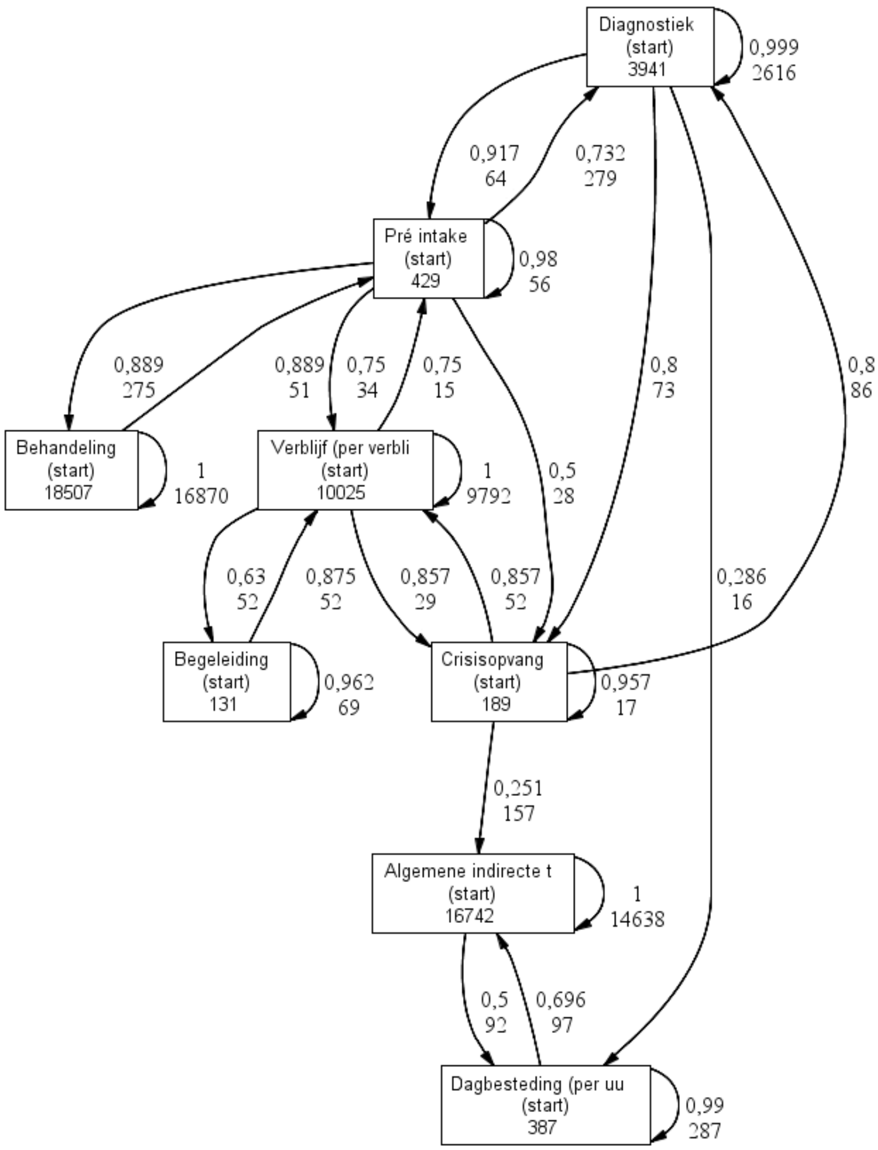


Figure 32 Heuristic mined model with activities at the highest aggregation level

Fuzzy model

- Closed care trajectories only
- Activities level 2 and professions level 2
- Activities executed by more than 1 resource are grouped and resources are renamed as "multiple_*name level1 activity*"
- Other filters: pervasive diagnosis only, care trajectories containing more than 5 activities, no waiting times longer than 60 days.

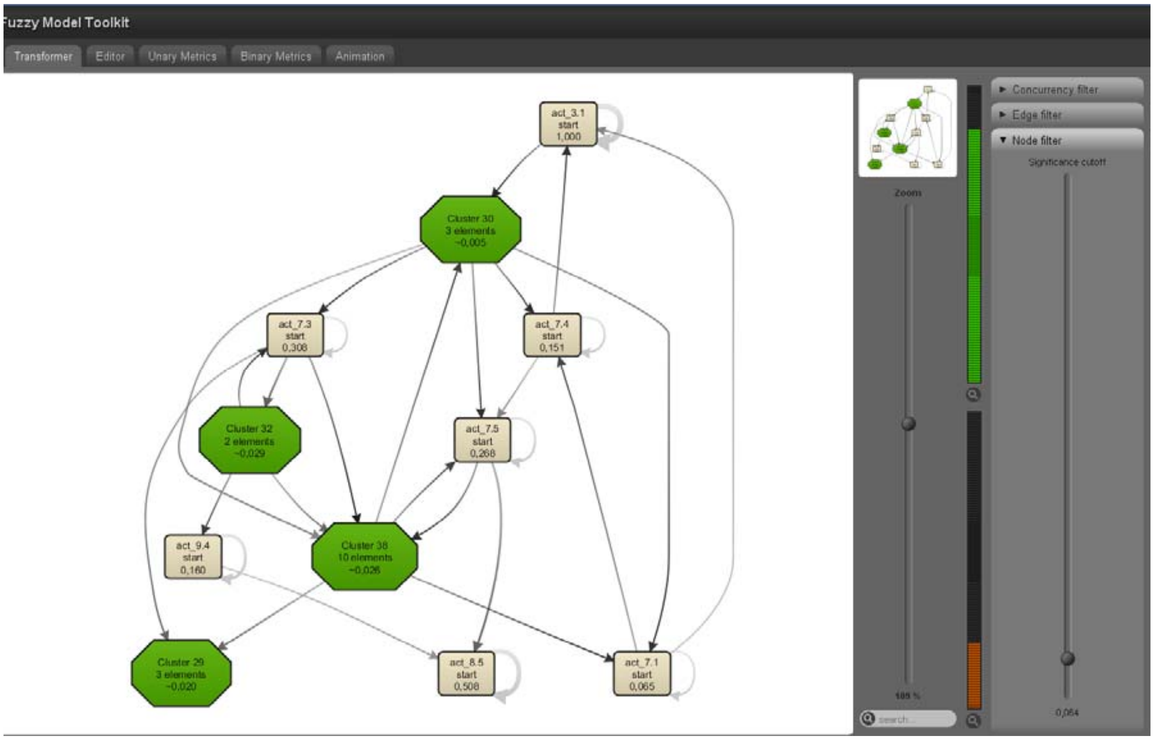


Figure 33 Fuzzy mined model for client group characterized by pervasive diagnosis, more than 5 activities, no waiting times longer than 60 days

Performance sequence diagram

- Closed care trajectories only
- Activities level 1 and professions level 1
- Activities executed by more than 1 resource are grouped and resources are renamed as "multiple_*name level1 activity*"

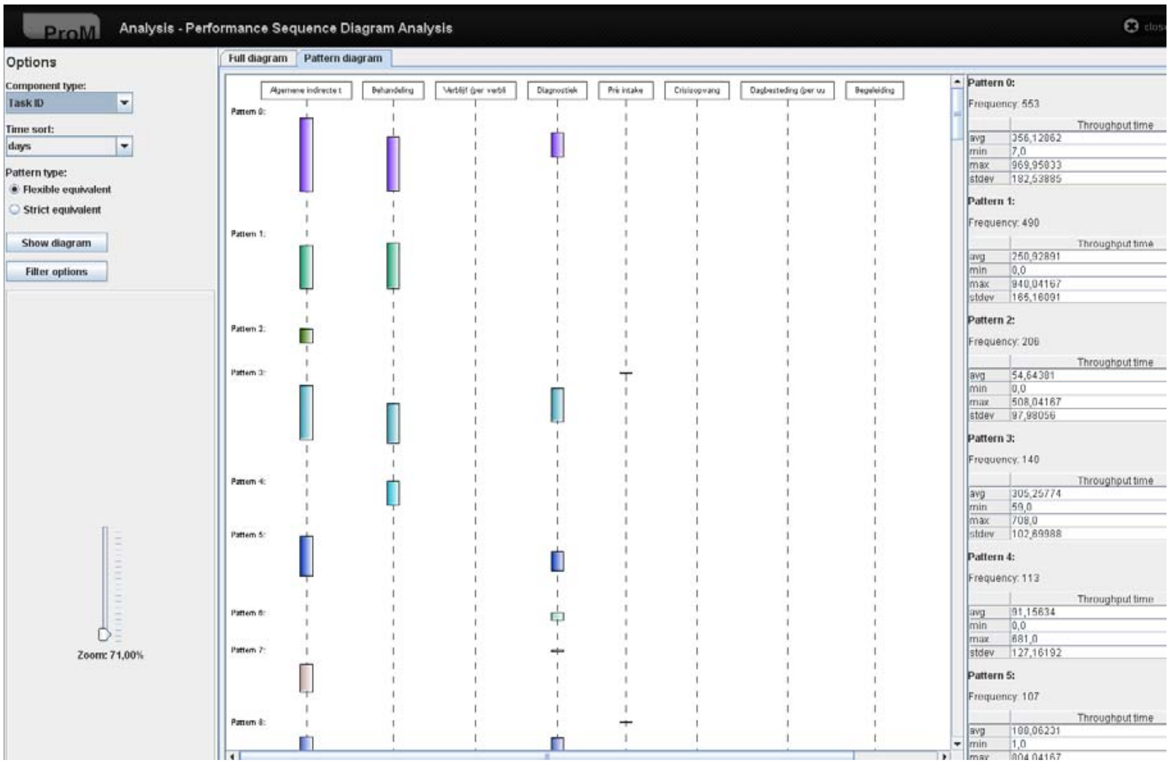


Figure 34 Performance sequence diagram with activities at the highest aggregation level

Dotted chart analysis

- Closed care trajectories only
- Activities level 1 and professions level 1
- Activities executed by more than 1 resource are grouped and resources are renamed as "multiple_*name level1 activity*"

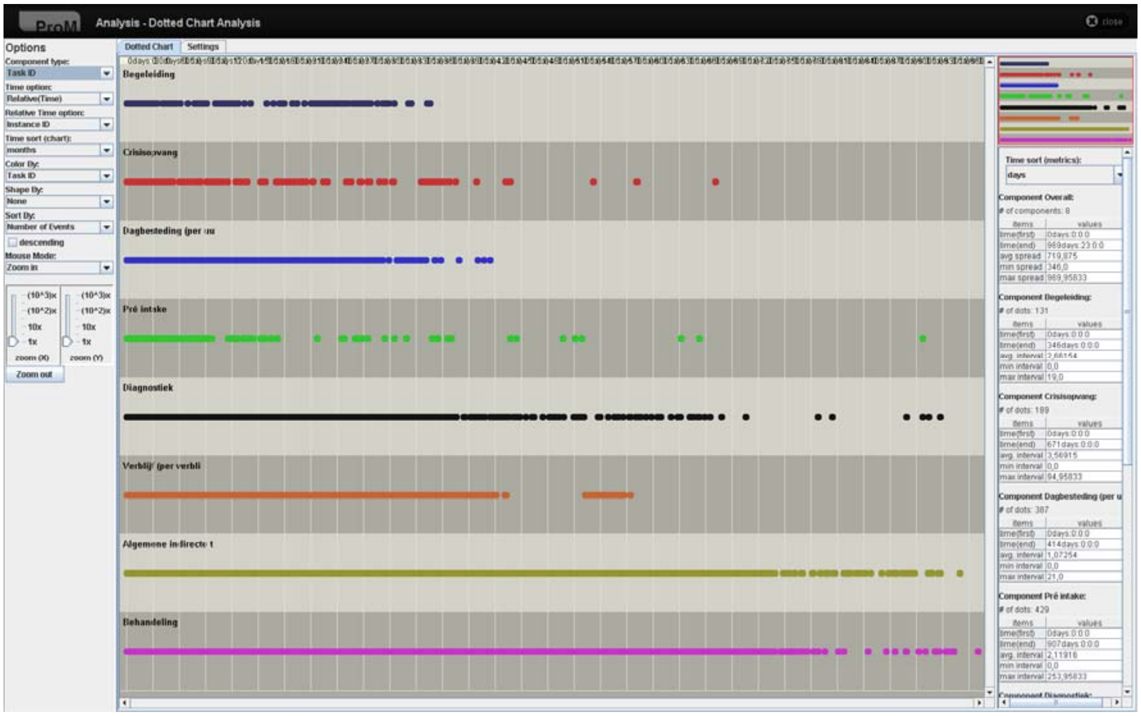


Figure 35 Dotted chart analysis 'task perspective'

Originatory by task matrix

- Closed care trajectories only
- Activities level 2 and professions level 2
- Activities executed by more than 1 resource are grouped and resources are renamed as "multiple_*name level1 activity*"
- Other filters: pervasive diagnosis only, care trajectories containing more than 5 activities, no waiting times longer than 60 days.

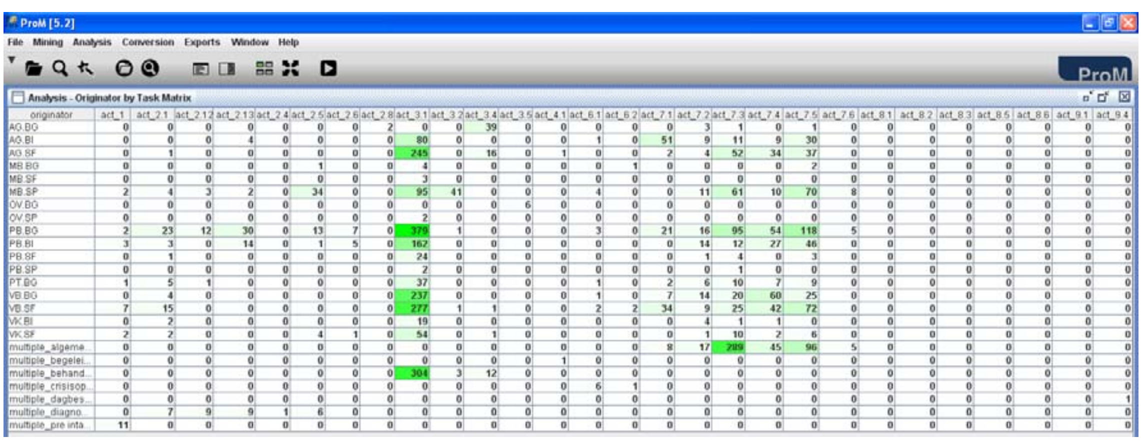


Figure 36 Originator by task matrix for client group characterized by pervasive diagnosis, more than 5 activities, no waiting times longer than 60 days

Appendix J: Results client group identification

Table 7 Summary results client grouping subtracted from dashboard statistics ProM

						# of activities per CT			# of activity types per CT			throughput time of CT (days)			ratio		
	# Care trajectories	# DBCs	# activities	# activity types	# originators	mean	min	max	mean	min	max	mean	min	max	TH/#act	#act/TH	Color
all trajectories closed	2127	2515	50531	35	24	23	1	663	4	1	17	239	0	970	10,39	0,10	
all pervasief trajectories closed	899	1072	16112	32	24	17	1	663	4	1	17	245	0	940	14,41	0,07	
pervasief trajectories closed ≥ 12 years old	456	535	10027	31	24	21	1	663	4	1	17	233	0	935	11,10	0,09	
pervasief trajectories closed < 12 years old	443	537	6085	23	17	13	1	259	3	1	11	256	0	940	19,69	0,05	
all trajectories closed > 5 activities	1396	1743	48500	35	24	34	6	663	5	1	17	319	0	970	9,38	0,11	
all pervasief trajectories closed > 5 activities	568	719	15330	32	24	26	6	663	6	1	17	335	4	940	12,88	0,08	
pervasief trajectories closed ≥ 12 years old, > 5 activities	281	353	9626	31	24	34	6	663	5	1	17	327	4	935	9,62	0,10	
pervasief trajectories closed < 12 years old, > 5 activities	287	366	5704	23	17	19	6	259	5	1	11	342	46	940	18,00	0,06	
all trajectories closed > 5 activities, < 30 days waiting time	191	197	16091	29	24	84	6	663	6	1	17	170	0	609	2,02	0,49	
all pervasief trajectories closed > 5 activities, < 30 days waiting time	47	48	3566	27	21	75	6	663	6	1	16	174	4	364	2,32	0,43	
pervasief trajectories closed ≥ 12 years old, > 5 activities, < 30 days waiting time	34	34	3029	26	21	89	6	663	6	1	16	177	4	364	1,99	0,50	
pervasief trajectories closed ≥ 12 years old, > 5 activities, < 60 days waiting time	102	107	5506	28	24	53	6	663	6	1	16	234	4	723	4,42	0,23	
all trajectories closed > 5 activities, < 90 days waiting time	761	825	35418	33	24	46	6	663	5	1	17	251	0	763	5,46	0,18	
all pervasief trajectories closed > 5 activities, < 90 days waiting time	274	293	9674	30	24	35	6	663	5	1	16	260	4	723	7,43	0,13	
pervasief trajectories closed ≥ 12 years old, > 5 activities, < 90 days waiting time	155	167	6934	28	24	44	6	663	5	1	16	264	4	723	6,00	0,17	
pervasief trajectories closed < 12 years old, > 5 activities, < 90 days waiting time	119	126	2740	20	16	23	6	259	5	1	11	255	46	713	11,09	0,09	
all trajectories closed > 5 activities, ≥ 30 days waiting time	1205	1546	32409	34	23	26	6	445	5	1	17	343	57	970	13,19	0,08	
all pervasief trajectories closed > 5 activities, ≥ 30 days waiting time	521	671	11764	29	20	22	6	312	5	1	17	349	72	940	15,86	0,06	
all trajectories closed > 5 activities, ≥ 90 days waiting time	635	918	13082	31	22	20	6	348	5	1	17	401	130	970	20,05	0,05	
all pervasief trajectories closed > 5 activities, ≥ 90 days waiting time	294	428	5656	26	19	19	6	291	5	1	17	404	139	940	21,26	0,05	
pervasief trajectories closed ≥ 12 years old, > 5 activities, ≥ 90 days waiting time	126	186	2692	24	19	21	6	291	5	1	17	403	154	935	19,19	0,05	
pervasief trajectories closed < 12 years old, > 5 activities, ≥ 90 days waiting time	168	240	2964	17	16	17	6	65	5	2	11	404	139	940	23,76	0,04	
all trajectories closed ≤ 5 activities	731	772	1851	19	17	2	1	5	1	1	5	86	0	826	43,00	0,02	
all pervasief trajectories closed ≤ 5 activities	331	353	782	15	15	2	1	5	1	1	4	90	0	804	45,00	0,02	
pervasief trajectories closed ≥ 12 years old, ≤ 5 activities	175	182	401	14	15	2	1	5	1	1	4	83	0	804	41,50	0,02	
pervasief trajectories closed < 12 years old, ≤ 5 activities	156	171	381	13	13	2	1	5	1	1	4	98	0	706	49,00	0,02	

Table 8 Relative occurrence activities at a level 2 coding level ordered at client groups

	all trajectories closed	all pervasief trajectories closed	pervasief trajectories closed ≥ 12 years old	pervasief trajectories closed < 12 years old	all trajectories closed > 5 activities	all pervasief trajectories closed > 5 activities	pervasief trajectories closed ≥ 12 years old, > 5	pervasief trajectories closed < 12 years old, > 5	all trajectories closed > 5 activities, < 30 days waiting	all pervasief trajectories closed > 5 activities, < 30 days	pervasief trajectories closed ≥ 12 years old, > 5	pervasief trajectories closed ≥ 12 years old, > 5	all trajectories closed > 5 activities, < 90 days waiting	all pervasief trajectories closed > 5 activities, < 90 days	pervasief trajectories closed ≥ 12 years old, > 5	pervasief trajectories closed < 12 years old, > 5	all trajectories closed > 5 activities, ≥ 30 days waiting	all pervasief trajectories closed > 5 activities, ≥ 30 days	all trajectories closed > 5 activities, ≥ 90 days waiting	all pervasief trajectories closed > 5 activities, ≥ 90 days	pervasief trajectories closed ≥ 12 years old, > 5	pervasief trajectories closed < 12 years old, > 5	all trajectories closed ≤ 5 activities	all pervasief trajectories closed ≤ 5 activities	pervasief trajectories closed ≥ 12 years old, ≤ 5	pervasief trajectories closed < 12 years old, ≤ 5
act_1	0,85%	0,95%	0,76%	1,27%	0,76%	0,87%	0,70%	1,18%	0,24%	0,39%	0,43%	0,51%	0,66%	0,84%	0,65%	1,31%	1,02%	1,02%	1,03%	0,94%	0,82%	1,05%	3,30%	2,43%	2,24%	2,63%
act_2.1	2,21%	2,16%	1,87%	2,65%	2,00%	1,91%	1,65%	2,33%	0,91%	0,70%	0,63%	1,22%	1,60%	1,51%	1,31%	2,01%	2,55%	2,27%	3,09%	2,58%	2,53%	2,63%	7,51%	7,16%	6,98%	7,35%
act_2.3	0,01%	0,02%	0,02%	0,02%	0,01%	0,02%	0,02%	0,02%	0,00%	0,00%	0,00%	0,02%	0,00%	0,00%	0,00%	0,00%	0,02%	0,03%	0,03%	0,05%	0,07%	0,03%	0,00%	0,00%	0,00%	0,00%
act_2.4	0,01%	0,01%	0,01%	0,02%	0,01%	0,01%	0,01%	0,02%	0,00%	0,00%	0,00%	0,00%	0,02%	0,01%	0,01%	0,00%	0,02%	0,02%	0,02%	0,02%	0,00%	0,03%	0,00%	0,00%	0,00%	0,00%
act_2.5	1,62%	2,01%	1,57%	2,73%	1,58%	1,98%	1,55%	2,70%	0,81%	1,12%	0,96%	1,07%	1,16%	1,48%	1,15%	2,30%	1,97%	2,24%	2,72%	2,83%	2,56%	3,07%	2,49%	2,56%	2,00%	3,15%
act_2.6	0,78%	0,90%	0,46%	1,63%	0,77%	0,94%	0,48%	1,72%	0,26%	0,11%	0,03%	0,24%	0,57%	0,63%	0,22%	1,68%	1,03%	1,19%	1,32%	1,47%	1,15%	1,75%	0,86%	0,13%	0,00%	0,26%
act_2.8	0,04%	0,03%	0,02%	0,03%	0,04%	0,03%	0,02%	0,04%	0,06%	0,06%	0,07%	0,04%	0,04%	0,02%	0,03%	0,00%	0,03%	0,02%	0,04%	0,04%	0,00%	0,07%	0,00%	0,00%	0,00%	0,00%
act_2.10	0,03%	0,02%	0,01%	0,03%	0,03%	0,02%	0,01%	0,04%	0,02%	0,03%	0,00%	0,00%	0,01%	0,02%	0,00%	0,07%	0,04%	0,02%	0,08%	0,02%	0,04%	0,00%	0,05%	0,00%	0,00%	0,00%
act_2.12	0,73%	0,85%	0,64%	1,20%	0,74%	0,87%	0,65%	1,25%	0,33%	0,28%	0,13%	0,45%	0,59%	0,69%	0,52%	1,13%	0,94%	1,05%	1,13%	1,19%	1,00%	1,35%	0,49%	0,38%	0,25%	0,53%
act_2.13	2,41%	3,11%	2,03%	4,90%	2,25%	2,69%	1,59%	4,56%	1,00%	0,84%	0,36%	1,07%	1,77%	1,88%	1,11%	3,83%	2,87%	3,26%	3,57%	4,08%	2,82%	5,23%	6,54%	11,25%	12,47%	9,97%
act_3.1	33,59%	37,74%	36,30%	40,10%	33,94%	38,38%	36,69%	41,23%	26,85%	27,87%	26,61%	34,94%	33,38%	38,15%	36,50%	42,34%	37,46%	41,57%	35,44%	38,77%	37,18%	40,22%	24,64%	25,06%	26,93%	23,10%
act_3.2	2,13%	2,59%	1,92%	3,70%	1,97%	2,47%	1,80%	3,59%	0,70%	0,79%	0,59%	0,84%	1,31%	1,72%	1,30%	2,77%	2,61%	2,98%	3,76%	3,75%	3,08%	4,35%	6,27%	4,99%	4,74%	5,25%
act_3.4	1,02%	0,71%	1,03%	0,18%	1,05%	0,74%	1,06%	0,19%	1,96%	2,16%	2,18%	1,25%	1,18%	0,83%	1,00%	0,40%	0,59%	0,31%	0,67%	0,58%	1,23%	0,00%	0,27%	0,13%	0,25%	0,00%
act_3.5	0,01%	0,04%	0,06%	0,00%	0,01%	0,04%	0,06%	0,00%	0,00%	0,00%	0,00%	0,11%	0,02%	0,06%	0,09%	0,00%	0,02%	0,05%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
act_3.6	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,01%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
act_4.1	0,19%	0,01%	0,02%	0,00%	0,19%	0,01%	0,02%	0,00%	0,22%	0,06%	0,07%	0,04%	0,19%	0,02%	0,03%	0,00%	0,18%	0,00%	0,20%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
act_4.2	0,08%	0,03%	0,00%	0,07%	0,08%	0,03%	0,00%	0,07%	0,12%	0,00%	0,00%	0,00%	0,10%	0,04%	0,00%	0,15%	0,05%	0,03%	0,00%	0,00%	0,00%	0,00%	0,05%	0,00%	0,00%	0,00%
act_6.1	0,32%	0,32%	0,40%	0,20%	0,32%	0,33%	0,40%	0,21%	0,31%	0,28%	0,30%	0,33%	0,31%	0,30%	0,35%	0,18%	0,32%	0,34%	0,33%	0,37%	0,52%	0,24%	0,43%	0,26%	0,50%	0,00%
act_6.2	0,05%	0,04%	0,07%	0,00%	0,05%	0,05%	0,07%	0,00%	0,06%	0,03%	0,03%	0,07%	0,05%	0,05%	0,07%	0,00%	0,05%	0,05%	0,05%	0,04%	0,07%	0,00%	0,11%	0,00%	0,00%	0,00%
act_7.1	1,97%	2,44%	2,55%	2,25%	1,93%	2,39%	2,51%	2,17%	1,42%	1,88%	2,05%	2,27%	1,67%	2,18%	2,28%	1,93%	2,19%	2,54%	2,65%	2,74%	3,12%	2,40%	2,97%	3,45%	3,49%	3,41%
act_7.2	3,21%	2,20%	2,35%	1,94%	3,18%	2,20%	2,38%	1,89%	2,31%	1,32%	1,16%	1,98%	3,10%	2,13%	2,18%	2,01%	3,61%	2,47%	3,39%	2,32%	2,90%	1,79%	4,00%	2,17%	1,75%	2,63%
act_7.3	12,63%	12,71%	12,93%	12,34%	12,27%	12,19%	12,48%	11,69%	9,35%	7,46%	7,96%	10,75%	11,34%	10,90%	11,09%	10,40%	13,73%	13,62%	14,80%	14,39%	16,05%	12,89%	21,93%	22,89%	23,69%	22,05%
act_7.4	3,32%	4,06%	4,64%	3,11%	3,35%	4,15%	4,69%	3,24%	2,52%	3,25%	3,60%	5,29%	3,24%	4,40%	4,98%	2,96%	3,76%	4,42%	3,65%	3,71%	3,94%	3,51%	2,70%	2,30%	3,49%	1,05%
act_7.5	12,01%	14,46%	11,81%	18,82%	11,91%	14,44%	11,83%	18,83%	6,81%	6,98%	6,31%	9,35%	10,51%	12,38%	10,08%	18,21%	14,44%	16,70%	15,68%	17,95%	16,35%	19,40%	14,80%	14,83%	11,22%	18,64%
act_7.6	0,10%	0,16%	0,22%	0,07%	0,10%	0,17%	0,23%	0,07%	0,17%	0,42%	0,36%	0,33%	0,12%	0,23%	0,26%	0,15%	0,07%	0,09%	0,05%	0,07%	0,15%	0,00%	0,00%	0,00%	0,00%	0,00%
act_7.7	0,01%	0,01%	0,02%	0,00%	0,01%	0,01%	0,02%	0,00%	0,01%	0,00%	0,00%	0,00%	0,01%	0,00%	0,00%	0,00%	0,02%	0,02%	0,02%	0,04%	0,07%	0,00%	0,00%	0,00%	0,00%	0,00%
act_7.8	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,01%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
act_8.1	12,79%	2,31%	3,71%	0,00%	13,25%	2,43%	3,87%	0,00%	24,98%	1,71%	2,01%	2,02%	17,06%	2,88%	4,02%	0,00%	7,43%	2,64%	2,95%	1,64%	3,46%	0	0,59%	0,00%	0,00%	0,00%
act_8.2	1,34%	0,20%	0,32%	0,00%	1,39%	0,21%	0,33%	0,00%	0,62%	0,25%	0,30%	0,31%	1,45%	0,29%	0,40%	0,00%	1,78%	0,20%	1,24%	0,07%	0,15%	0,00%	0,00%	0,00%	0,00%	0,00%
act_8.3	0,38%	0,27%	0,43%	0,00%	0,39%	0,28%	0,45%	0,00%	0,68%	0,31%	0,36%	0,44%	0,47%	0,25%	0,35%	0,00%	0,25%	0,27%	0,18%	0,34%	0,71%	0,00%	0,00%	0,00%	0,00%	0,00%
act_8.5	5,22%	6,98%	9,74%	2,42%	5,42%	7,33%	10,15%	2,58%	14,83%	31,52%	32,26%	17,74%	6,74%	11,62%	14,09%	5,37%	0,75%	0,00%	1,87%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
act_8.6	0,19%	0,55%	0,89%	0,00%	0,19%	0,58%	0,93%	0,00%	0,17%	0,76%	0,89%	1,60%	0,26%	0,91%	1,27%	0,00%	0,20%	0,53%	0,01%	0,02%	0,04%	0,00%	0,00%	0,00%	0,00%	0,00%
act_9.1	0,02%	0,06%	0,09%	0,00%	0,02%	0,06%	0,09%	0,00%	0,06%	0,25%	0,30%	0,16%	0,03%	0,09%	0,13%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
act_9.3	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
act_9.4	0,75%	2,09%	3,14%	0,36%	0,78%	2,20%	3,27%	0,39%	2,25%	9,17%	10,07%	5,58%	1,05%	3,48%	4,54%	0,80%	0,04%	0,09%	0,03%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Color																										

Table 9 Relative occurrence activities at a level 1 coding level ordered at client groups

	all trajectories closed	all pervasief trajectories closed	pervasief trajectories closed ≥ 12 years old	pervasief trajectories closed < 12 years old	all trajectories closed > 5 activities	all pervasief trajectories closed > 5 activities	pervasief trajectories closed ≥ 12 years old, > 5 activities	pervasief trajectories closed < 12 years old, > 5 activities	all trajectories closed > 5 activities, < 30 days waiting time	all pervasief trajectories closed > 5 activities, < 30 days	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 30 days	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 60 days	all trajectories closed > 5 activities, < 90 days waiting time	all pervasief trajectories closed > 5 activities, < 90 days	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 90 days	pervasief trajectories closed < 12 years old, > 5 activities, < 90 days	all trajectories closed > 5 activities, ≥ 30 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 30 days	all trajectories closed > 5 activities, ≥ 90 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 90 days	pervasief trajectories closed ≥ 12 years old, > 5 activities, ≥ 90 days	pervasief trajectories closed < 12 years old, > 5 activities, ≥ 90 days	all trajectories closed ≤ 5 activities	all pervasief trajectories closed ≤ 5 activities	pervasief trajectories closed ≥ 12 years old, ≤ 5 activities	pervasief trajectories closed < 12 years old, ≤ 5 activities
act_1	0,85%	0,95%	0,76%	1,27%	0,76%	0,87%	0,70%	1,18%	0,24%	0,39%	0,43%	0,51%	0,66%	0,84%	0,65%	1,31%	1,02%	1,02%	1,03%	0,94%	0,82%	1,05%	3,30%	2,43%	2,24%	2,63%
act_2	7,83%	9,10%	6,61%	13,20%	7,44%	8,47%	5,98%	12,66%	3,38%	3,14%	2,18%	4,11%	5,76%	6,24%	4,35%	11,02%	9,46%	10,08%	12,01%	12,27%	10,18%	14,17%	17,94%	21,48%	21,70%	21,26%
act_3	36,76%	41,07%	39,30%	43,98%	36,97%	41,62%	39,61%	45,02%	29,51%	30,82%	29,38%	37,14%	35,89%	40,76%	38,88%	45,51%	40,67%	44,90%	39,88%	43,10%	41,49%	44,57%	31,17%	30,18%	31,92%	28,35%
act_4	0,26%	0,04%	0,02%	0,07%	0,27%	0,04%	0,02%	0,07%	0,35%	0,06%	0,07%	0,04%	0,29%	0,06%	0,03%	0,15%	0,23%	0,03%	0,20%	0,00%	0,00%	0,00%	0,05%	0,00%	0,00%	0,00%
act_6	0,38%	0,37%	0,47%	0,20%	0,37%	0,37%	0,47%	0,21%	0,36%	0,31%	0,33%	0,40%	0,36%	0,35%	0,42%	0,18%	0,37%	0,39%	0,38%	0,41%	0,59%	0,24%	0,54%	0,26%	0,50%	0,00%
act_7	33,25%	36,03%	34,52%	38,52%	32,75%	35,54%	34,14%	37,90%	22,58%	21,31%	21,43%	29,97%	29,99%	32,22%	30,86%	35,66%	37,80%	39,85%	40,23%	41,21%	42,57%	39,98%	46,41%	45,65%	43,64%	47,77%
act_8	19,91%	10,30%	15,09%	2,42%	20,65%	10,83%	15,72%	2,58%	41,27%	34,55%	35,82%	22,10%	25,97%	15,95%	20,13%	5,37%	10,41%	3,64%	6,24%	2,07%	4,35%	0,00%	0,59%	0,00%	0,00%	0,00%
act_9	0,77%	2,15%	3,23%	0,36%	0,80%	2,26%	3,37%	0,39%	2,31%	9,42%	10,37%	5,74%	1,08%	3,58%	4,67%	0,80%	0,05%	0,09%	0,03%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Color																										

Table 10 Absolute occurrence activities at a level 1 coding level ordered at client groups

	all trajectories closed	all pervasief trajectories closed	pervasief trajectories closed ≥ 12 years old	pervasief trajectories closed < 12 years old	all trajectories closed > 5 activities	all pervasief trajectories closed > 5 activities	pervasief trajectories closed ≥ 12 years old, > 5 activities	pervasief trajectories closed < 12 years old, > 5 activities	all trajectories closed > 5 activities, < 30 days waiting time	all pervasief trajectories closed > 5 activities, < 30 days	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 30 days	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 60 days	all trajectories closed > 5 activities, < 90 days waiting time	all pervasief trajectories closed > 5 activities, < 90 days	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 90 days	pervasief trajectories closed < 12 years old, > 5 activities, < 90 days	all trajectories closed > 5 activities, ≥ 30 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 30 days	all trajectories closed > 5 activities, ≥ 90 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 90 days	pervasief trajectories closed ≥ 12 years old, > 5 activities, ≥ 90 days	pervasief trajectories closed < 12 years old, > 5 activities, ≥ 90 days	all trajectories closed ≤ 5 activities	all pervasief trajectories closed ≤ 5 activities	pervasief trajectories closed ≥ 12 years old, ≤ 5 activities	pervasief trajectories closed < 12 years old, ≤ 5 activities
act_1	429	153	76	77	368	134	67	67	38	14	13	28	233	81	45	36	330	120	135	53	22	31	61	19	9	10
act_2	3941	1466	663	803	3609	1298	576	722	544	112	66	226	2038	604	302	302	3065	1186	1571	694	274	420	332	168	87	81
act_3	18507	6617	3941	2676	17930	6381	3813	2568	4748	1099	890	2045	12713	3943	2696	1247	13182	5282	5217	2438	1117	1321	577	236	128	108
act_4	131	6	2	4	130	6	2	4	56	2	2	2	104	6	2	4	74	4	26	0	0	0	1	0	0	0
act_6	189	59	47	12	179	57	45	12	58	11	10	22	129	34	29	5	121	46	50	23	16	7	10	2	2	0
act_7	16742	5805	3461	2344	15883	5448	3286	2162	3634	760	649	1650	10620	3117	2140	977	12249	4688	5263	2331	1146	1185	859	357	175	182
act_8	10025	1660	1513	147	10014	1660	1513	147	6641	1232	1085	1217	9198	1543	1396	147	3373	428	816	117	117	0	11	0	0	0
act_9	387	346	324	22	387	346	324	22	372	336	314	316	383	346	324	22	15	10	4	0	0	0	0	0	0	0
Color																										

Table 11 Relative occurrence originators at a level 2 coding level ordered at client groups

Originator	all trajectories closed	all pervasief trajectories closed	pervasief trajectories closed ≥ 12 years old	pervasief trajectories closed < 12 years old	all trajectories closed > 5 activities	all pervasief trajectories closed > 5 activities	pervasief trajectories closed ≥ 12 years old, > 5 activities	pervasief trajectories closed < 12 years old, > 5 activities	all trajectories closed > 5 activities, < 30 days waiting time	all pervasief trajectories closed > 5 activities, < 30 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 30 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 60 days waiting time	all trajectories closed > 5 activities, < 90 days waiting time	all pervasief trajectories closed > 5 activities, < 90 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 90 days waiting time	pervasief trajectories closed < 12 years old, > 5 activities, < 90 days waiting time	all trajectories closed > 5 activities, ≥ 30 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 30 days waiting time	all trajectories closed > 5 activities, ≥ 90 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 90 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, ≥ 90 days waiting time	pervasief trajectories closed < 12 years old, > 5 activities, ≥ 90 days waiting time	all trajectories closed ≤ 5 activities	all pervasief trajectories closed ≤ 5 activities	pervasief trajectories closed ≥ 12 years old, ≤ 5 activities	pervasief trajectories closed < 12 years old, ≤ 5 activities
AG.BG	0,22%	0,37%	0,46%	0,21%	0,23%	0,39%	0,48%	0,23%	0,42%	1,66%	1,52%	0,84%	0,27%	0,61%	0,66%	0,47%	0,13%	0,00%	0,09%	0,00%	0,00%	0,00%	0,32%	0,00%	0,00%	0,00%
AG.BI	1,78%	2,21%	2,82%	1,20%	1,76%	2,13%	2,73%	1,12%	2,49%	4,15%	4,79%	3,54%	1,99%	2,62%	3,04%	1,53%	1,39%	1,52%	1,13%	1,31%	1,93%	0,74%	2,38%	3,71%	4,99%	2,36%
AG.SF	4,80%	3,34%	4,82%	0,90%	4,92%	3,47%	4,99%	0,91%	6,54%	4,88%	5,41%	7,12%	5,80%	4,75%	6,10%	1,31%	4,12%	3,04%	2,55%	1,29%	2,12%	0,54%	1,57%	0,77%	0,75%	0,79%
MB.BG	0,50%	0,32%	0,26%	0,41%	0,43%	0,26%	0,21%	0,35%	0,35%	0,25%	0,20%	0,15%	0,37%	0,28%	0,16%	0,58%	0,47%	0,26%	0,58%	0,23%	0,33%	0,14%	2,38%	1,28%	1,50%	1,31%
MB.SF	0,04%	0,02%	0,03%	0,00%	0,04%	0,02%	0,03%	0,00%	0,06%	0,08%	0,10%	0,05%	0,03%	0,03%	0,04%	0,00%	0,03%	0,00%	0,08%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
MB.SP	4,93%	6,21%	7,11%	4,73%	4,87%	6,19%	7,08%	4,70%	3,47%	5,33%	4,72%	6,27%	4,50%	6,60%	7,18%	5,11%	5,56%	6,45%	5,86%	5,50%	6,80%	4,32%	6,65%	6,65%	7,98%	5,25%
multiple_algemene indirecte tijd	11,41%	11,54%	10,88%	12,62%	11,12%	11,16%	10,56%	12,17%	8,46%	6,06%	6,27%	8,36%	9,84%	9,01%	8,74%	9,71%	12,44%	12,70%	14,59%	14,82%	15,23%	14,44%	19,07%	19,05%	18,70%	19,42%
multiple_begeleiding	0,06%	0,01%	0,01%	0,00%	0,07%	0,01%	0,01%	0,00%	0,07%	0,03%	0,03%	0,02%	0,07%	0,01%	0,01%	0,00%	0,07%	0,00%	0,07%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
multiple_behandeling	7,23%	9,23%	6,82%	13,20%	7,41%	9,55%	6,93%	13,97%	6,63%	6,09%	4,42%	5,79%	6,77%	7,86%	5,99%	12,59%	7,80%	10,60%	9,14%	12,45%	9,36%	15,25%	2,43%	2,94%	4,24%	1,58%
multiple_crisisopvang	0,11%	0,11%	0,14%	0,05%	0,11%	0,11%	0,15%	0,05%	0,11%	0,08%	0,10%	0,13%	0,11%	0,11%	0,14%	0,04%	0,11%	0,12%	0,09%	0,11%	0,15%	0,07%	0,00%	0,00%	0,00%	0,00%
multiple_dagbesteding	0,00%	0,01%	0,01%	0,00%	0,00%	0,01%	0,01%	0,00%	0,01%	0,03%	0,03%	0,02%	0,00%	0,01%	0,01%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
multiple_diagnostiek	0,92%	1,19%	0,96%	1,58%	0,91%	1,18%	0,95%	1,58%	0,34%	0,39%	0,26%	0,58%	0,58%	0,62%	0,53%	0,84%	1,20%	1,42%	1,82%	2,14%	2,01%	2,26%	1,19%	1,41%	1,25%	1,58%
multiple_pre intake	0,51%	0,52%	0,33%	0,84%	0,44%	0,48%	0,30%	0,79%	0,10%	0,14%	0,17%	0,20%	0,35%	0,42%	0,26%	0,84%	0,61%	0,00%	0,67%	0,58%	0,41%	0,74%	2,32%	1,41%	1,00%	1,58%
OV.BG	0,01%	0,04%	0,06%	0,00%	0,01%	0,04%	0,06%	0,00%	0,01%	0,00%	0,00%	0,11%	0,02%	0,06%	0,09%	0,00%	0,02%	0,05%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
OV.SP	0,30%	0,41%	0,11%	0,90%	0,27%	0,37%	0,07%	0,86%	0,01%	0,00%	0,00%	0,04%	0,09%	0,12%	0,04%	0,33%	0,40%	0,48%	0,75%	0,78%	0,15%	1,35%	1,19%	1,28%	1,00%	1,58%
PB.BG	17,99%	17,99%	16,15%	21,02%	17,81%	17,55%	15,68%	20,71%	10,99%	13,77%	12,78%	14,15%	16,57%	16,50%	13,99%	22,85%	21,19%	18,69%	21,17%	19,34%	20,02%	18,73%	22,91%	26,60%	27,43%	25,72%
PB.BI	5,39%	7,96%	6,49%	10,37%	5,48%	8,22%	6,74%	10,71%	3,29%	1,77%	2,01%	5,21%	4,80%	6,95%	5,88%	9,64%	6,56%	10,18%	7,32%	10,40%	8,95%	11,71%	3,19%	2,81%	0,50%	5,25%
PB.SF	0,38%	0,24%	0,37%	0,02%	0,39%	0,25%	0,38%	0,02%	0,68%	0,11%	0,13%	0,60%	0,49%	0,34%	0,48%	0,00%	0,25%	0,29%	0,12%	0,09%	0,15%	0,03%	0,00%	0,00%	0,00%	0,00%
PB.SP	0,76%	0,03%	0,05%	0,00%	0,76%	0,03%	0,05%	0,00%	0,84%	0,00%	0,00%	0,05%	0,80%	0,04%	0,06%	0,00%	0,71%	0,04%	0,63%	0,02%	0,04%	0,00%	0,92%	0,00%	0,00%	0,00%
PT.BG	3,65%	1,32%	1,15%	1,61%	3,69%	1,38%	1,17%	1,72%	3,26%	0,79%	0,63%	1,44%	3,89%	1,58%	1,40%	2,04%	3,91%	1,56%	3,16%	1,03%	0,59%	1,42%	2,59%	0,26%	0,50%	0,00%
VB.BG	1,78%	2,87%	4,62%	0,00%	1,84%	2,99%	4,77%	0,00%	2,16%	4,07%	4,79%	6,68%	2,29%	4,49%	6,26%	0,00%	1,68%	2,67%	0,63%	0,44%	0,93%	0,00%	0,22%	0,51%	1,00%	0,00%
VB.SF	14,73%	19,12%	15,64%	24,85%	14,27%	18,66%	15,21%	24,49%	4,88%	5,08%	4,03%	8,85%	11,77%	15,07%	11,74%	23,50%	18,93%	22,78%	21,01%	24,81%	24,15%	25,41%	26,74%	28,01%	25,94%	30,18%
VK.BI	0,15%	0,21%	0,33%	0,00%	0,15%	0,22%	0,34%	0,00%	0,16%	0,42%	0,50%	0,49%	0,14%	0,31%	0,43%	0,00%	0,15%	0,15%	0,19%	0,05%	0,11%	0,00%	0,00%	0,00%	0,00%	0,00%
VK.SF	1,67%	2,32%	2,08%	2,71%	1,60%	2,27%	2,04%	2,67%	1,11%	0,90%	0,96%	1,51%	1,42%	2,10%	1,96%	2,45%	1,85%	2,69%	2,11%	2,56%	2,23%	2,87%	3,35%	3,33%	3,24%	3,41%
no originator	20,68%	12,44%	18,31%	2,78%	21,44%	13,08%	19,08%	2,96%	43,58%	43,94%	46,16%	27,83%	27,05%	19,52%	24,79%	6,17%	10,45%	4,31%	6,27%	2,07%	4,35%	0,00%	0,59%	0,00%	0,00%	0,00%
Color																										

Table 12 Relative occurrence originators at a level 1 coding level ordered at client groups

	all trajectories closed	all pervasief trajectories closed	pervasief trajectories closed ≥ 12 years old	pervasief trajectories closed < 12 years old	all trajectories closed > 5 activities	all pervasief trajectories closed > 5 activities	pervasief trajectories closed ≥ 12 years old, > 5 activities	pervasief trajectories closed < 12 years old, > 5 activities	all trajectories closed > 5 activities, < 30 days waiting time	all pervasief trajectories closed > 5 activities, < 30 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 30 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 60 days waiting time	all trajectories closed > 5 activities, < 90 days waiting time	all pervasief trajectories closed > 5 activities, < 90 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 90 days waiting time	pervasief trajectories closed < 12 years old, > 5 activities, < 90 days waiting time	all trajectories closed > 5 activities, ≥ 30 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 30 days waiting time	all trajectories closed > 5 activities, ≥ 90 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 90 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, ≥ 90 days waiting time	pervasief trajectories closed < 12 years old, > 5 activities, ≥ 90 days waiting time	all trajectories closed ≤ 5 activities	all pervasief trajectories closed ≤ 5 activities	pervasief trajectories closed ≥ 12 years old, ≤ 5 activities	pervasief trajectories closed < 12 years old, ≤ 5 activities
AG	6,79%	5,92%	8,10%	2,32%	6,90%	5,99%	8,20%	2,26%	9,45%	10,68%	11,72%	11,50%	8,06%	7,97%	9,81%	3,32%	5,64%	4,57%	3,77%	2,60%	4,05%	1,28%	4,27%	4,48%	5,74%	3,15%
MB	5,47%	6,55%	7,40%	5,14%	5,34%	6,47%	7,31%	5,05%	3,88%	5,66%	5,02%	6,47%	4,90%	6,91%	7,38%	5,69%	6,06%	6,72%	6,51%	5,73%	7,13%	4,45%	9,02%	7,93%	9,48%	6,56%
multiple_algemene indirecte tijd	11,41%	11,54%	10,88%	12,62%	11,12%	11,16%	10,56%	12,17%	8,46%	6,06%	6,27%	8,36%	9,84%	9,01%	8,74%	9,71%	12,44%	12,70%	14,59%	14,82%	15,23%	14,44%	19,07%	19,05%	18,70%	19,42%
multiple_begeleiding	0,06%	0,01%	0,01%	0,00%	0,07%	0,01%	0,01%	0,00%	0,07%	0,03%	0,03%	0,02%	0,07%	0,01%	0,01%	0,00%	0,07%	0,00%	0,07%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
multiple_behandeling	7,23%	9,23%	6,82%	13,20%	7,41%	9,55%	6,93%	13,97%	6,63%	6,09%	4,42%	5,79%	6,77%	7,86%	5,99%	12,59%	7,80%	10,60%	9,14%	12,45%	9,36%	15,25%	2,43%	2,94%	4,24%	1,58%
multiple_crisisopvang	0,11%	0,11%	0,14%	0,05%	0,11%	0,11%	0,15%	0,05%	0,11%	0,08%	0,10%	0,13%	0,11%	0,11%	0,14%	0,04%	0,11%	0,12%	0,09%	0,11%	0,15%	0,07%	0,00%	0,00%	0,00%	0,00%
multiple_dagbesteding	0,00%	0,01%	0,01%	0,00%	0,00%	0,01%	0,01%	0,00%	0,01%	0,03%	0,03%	0,02%	0,00%	0,01%	0,01%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
multiple_diagnostiek	0,92%	1,19%	0,96%	1,58%	0,91%	1,18%	0,95%	1,58%	0,34%	0,39%	0,26%	0,58%	0,58%	0,62%	0,53%	0,84%	1,20%	1,42%	1,82%	2,14%	2,01%	2,26%	1,19%	1,41%	1,25%	1,58%
multiple_pre intake	0,51%	0,52%	0,33%	0,84%	0,44%	0,48%	0,30%	0,79%	0,10%	0,14%	0,17%	0,20%	0,35%	0,42%	0,26%	0,84%	0,61%	0,00%	0,67%	0,58%	0,41%	0,74%	2,32%	1,41%	1,00%	1,58%
OV	0,32%	0,45%	0,17%	0,90%	0,28%	0,40%	0,14%	0,86%	0,01%	0,00%	0,00%	0,15%	0,11%	0,19%	0,13%	0,33%	0,42%	0,53%	0,75%	0,78%	0,15%	1,35%	1,19%	1,28%	1,00%	1,58%
PB	24,53%	26,21%	23,06%	31,41%	24,43%	26,05%	22,85%	31,44%	15,81%	15,65%	14,92%	20,01%	22,66%	23,83%	20,41%	32,48%	28,72%	29,20%	29,22%	29,84%	29,16%	30,47%	27,01%	29,41%	27,93%	30,97%
PT	3,65%	1,32%	1,15%	1,61%	3,69%	1,38%	1,17%	1,72%	3,26%	0,79%	0,63%	1,44%	3,89%	1,58%	1,40%	2,04%	3,91%	1,56%	3,16%	1,03%	0,59%	1,42%	2,59%	0,26%	0,50%	0,00%
VB	16,51%	21,99%	20,26%	24,85%	16,11%	21,66%	19,98%	24,49%	7,04%	9,14%	8,82%	15,53%	14,06%	19,56%	18,00%	23,50%	20,61%	25,45%	21,64%	25,25%	25,08%	25,41%	26,96%	28,52%	26,93%	30,18%
VK	1,81%	2,53%	2,41%	2,71%	1,75%	2,49%	2,38%	2,67%	1,27%	1,32%	1,45%	2,00%	1,55%	2,41%	2,39%	2,45%	1,99%	2,84%	2,30%	2,62%	2,34%	2,87%	3,35%	3,33%	3,24%	3,41%
no originator	20,68%	12,44%	18,31%	2,78%	21,44%	13,08%	19,08%	2,96%	43,58%	43,94%	46,16%	27,83%	27,05%	19,52%	24,79%	6,17%	10,45%	4,31%	6,27%	2,07%	4,35%	0,00%	0,59%	0,00%	0,00%	0,00%
Color																										

Table 13 Absolute occurrence originators at a level 1 coding level ordered at client groups

	all trajectories closed	all pervasief trajectories closed	pervasief trajectories closed ≥ 12 years old	pervasief trajectories closed < 12 years old	all trajectories closed > 5 activities	all pervasief trajectories closed > 5 activities	pervasief trajectories closed ≥ 12 years old, > 5 activities	pervasief trajectories closed < 12 years old, > 5 activities	all trajectories closed > 5 activities, < 30 days waiting time	all pervasief trajectories closed > 5 activities, < 30 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 30 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 60 days waiting time	all trajectories closed > 5 activities, < 90 days waiting time	all pervasief trajectories closed > 5 activities, < 90 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 90 days waiting time	pervasief trajectories closed < 12 years old, > 5 activities, < 90 days waiting time	all trajectories closed > 5 activities, ≥ 30 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 30 days waiting time	all trajectories closed > 5 activities, ≥ 90 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 90 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, ≥ 90 days waiting time	pervasief trajectories closed < 12 years old, > 5 activities, ≥ 90 days waiting time	all trajectories closed ≤ 5 activities	all pervasief trajectories closed ≤ 5 activities	pervasief trajectories closed ≥ 12 years old, ≤ 5 activities	pervasief trajectories closed < 12 years old, ≤ 5 activities
AG	3420	953	812	141	3347	918	789	129	1521	381	355	633	2854	771	680	91	1826	537	493	147	109	38	79	35	23	12
MB	2755	1055	742	313	2588	992	704	288	625	202	152	356	1736	668	512	156	1963	790	852	324	192	132	167	62	38	25
multiple_algemene indirecte tijd	5746	1859	1091	768	5393	1710	1016	694	1361	216	190	460	3485	872	606	266	4032	1494	1908	838	410	428	353	149	75	74
multiple_begeleiding	32	1	1	0	32	1	1	0	11	1	1	1	23	1	1	0	21	0	9	0	0	0	0	0	0	0
multiple_behandeling	3639	1487	684	803	3594	1464	667	797	1066	217	134	319	2398	760	415	345	2528	1247	1196	704	252	452	45	23	17	6
multiple_crisisopvang	57	17	14	3	51	17	14	3	17	3	3	7	39	11	10	1	34	14	12	6	4	2	0	0	0	0
multiple_dagbesteding	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
multiple_diagnostiek	465	192	96	96	443	181	91	90	55	14	8	32	205	60	37	23	388	167	238	121	54	67	22	11	5	6
multiple_pre intake	255	84	33	51	212	74	29	45	16	5	5	11	124	41	18	23	196	0	88	33	11	22	43	11	4	6
OV	160	72	17	55	138	62	13	49	2	0	0	8	40	18	9	9	136	62	98	44	4	40	22	10	4	6
PB	12349	4223	2312	1911	11849	3993	2200	1793	2543	558	452	1102	8026	2305	1415	890	9306	3435	3823	1688	785	903	500	230	112	118
PT	1838	213	115	98	1790	211	113	98	524	28	19	79	1377	153	97	56	1266	183	413	58	16	42	48	2	2	0
VB	8311	3543	2031	1512	7812	3320	1923	1397	1133	326	267	855	4981	1892	1248	644	6679	2994	2831	1428	675	753	499	223	108	115
VK	912	407	242	165	850	381	229	152	204	47	44	110	549	233	166	67	646	334	301	148	63	85	62	26	13	13
no originator	10411	2005	1836	169	10400	2005	1836	169	7012	1567	1398	1532	9579	1888	1719	169	3387	507	820	117	117	0	11	0	0	0
Color																										

Table 14 Relative occurrence first activities at a level 1 coding level ordered at client groups

	all trajectories closed	all pervasief trajectories closed	pervasief trajectories closed ≥ 12 years old	pervasief trajectories closed < 12 years old	all trajectories closed > 5 activities	all pervasief trajectories closed > 5 activities	pervasief trajectories closed ≥ 12 years old, > 5 activities	pervasief trajectories closed < 12 years old, > 5 activities	all trajectories closed > 5 activities, < 30 days waiting time	all pervasief trajectories closed > 5 activities, < 30 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 30 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 60 days waiting time	all trajectories closed > 5 activities, < 90 days waiting time	all pervasief trajectories closed > 5 activities, < 90 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 90 days waiting time	pervasief trajectories closed < 12 years old, > 5 activities, < 90 days waiting time	all trajectories closed > 5 activities, ≥ 30 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 30 days waiting time	all trajectories closed > 5 activities, ≥ 90 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 90 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, ≥ 90 days waiting time	pervasief trajectories closed < 12 years old, > 5 activities, ≥ 90 days waiting time	all trajectories closed ≤ 5 activities	all pervasief trajectories closed ≤ 5 activities	pervasief trajectories closed ≥ 12 years old, ≤ 5 activities	pervasief trajectories closed < 12 years old, ≤ 5 activities
act_1	10,72%	10,57%	7,46%	13,54%	15,62%	14,09%	10,68%	17,42%	7,33%	8,51%	11,77%	11,77%	17,48%	17,15%	13,55%	21,85%	16,93%	14,59%	13,39%	11,22%	7,14%	14,29%	6,57%	4,53%	2,86%	14,10%
act_2	20,73%	20,02%	20,40%	19,64%	20,27%	15,14%	14,59%	15,68%	19,37%	17,02%	11,76%	17,65%	20,24%	15,69%	14,84%	16,81%	20,42%	14,97%	20,31%	14,63%	14,29%	14,88%	22,44%	28,40%	29,71%	26,92%
act_3	25,86%	29,92%	32,90%	26,86%	26,65%	31,87%	35,94%	27,87%	29,84%	36,17%	41,18%	37,26%	29,17%	33,94%	39,35%	26,89%	26,14%	31,48%	23,62%	29,93%	31,75%	28,57%	26,68%	26,59%	28,00%	25,00%
act_4	0,14%	0,00%	0,00%	0,00%	0,14%	0,00%	0,00%	0,00%	0,52%	0,00%	0,00%	0,00%	0,26%	0,00%	0,00%	0,00%	0,08%	0,00%	0,00%	0,00%	0,00%	0,00%	0,14%	0,00%	0,00%	0,00%
act_6	0,66%	0,11%	0,22%	0,00%	0,72%	0,18%	0,36%	0,00%	2,10%	0,00%	0,00%	0,00%	0,92%	0,00%	0,00%	0,00%	0,50%	0,19%	0,47%	0,34%	0,79%	0,00%	0,55%	0,00%	0,00%	0,00%
act_7	39,02%	38,60%	37,72%	39,73%	33,81%	37,50%	36,30%	38,68%	20,94%	25,53%	20,59%	28,43%	26,81%	30,66%	28,39%	33,61%	35,85%	38,58%	42,21%	43,88%	46,03%	42,26%	42,96%	40,48%	39,43%	33,97%
act_8	2,82%	0,67%	1,10%	0,23%	2,72%	1,06%	1,78%	0,35%	19,37%	10,64%	11,77%	3,92%	4,99%	2,19%	3,23%	0,84%	0,08%	0,19%	0,00%	0,00%	0,00%	0,00%	0,68%	0,00%	0,00%	0,00%
act_9	0,05%	0,11%	0,22%	0,00%	0,07%	0,18%	0,36%	0,00%	0,52%	2,13%	2,94%	0,98%	0,13%	0,37%	0,65%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Color																										

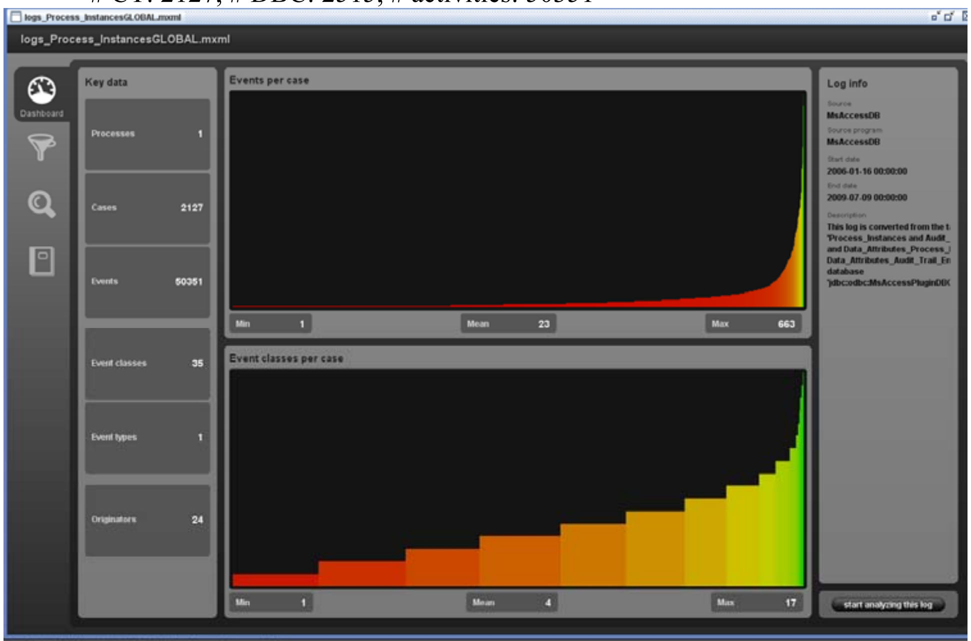
Table 15 Relative occurrence last activities at a level 1 coding level ordered at client groups

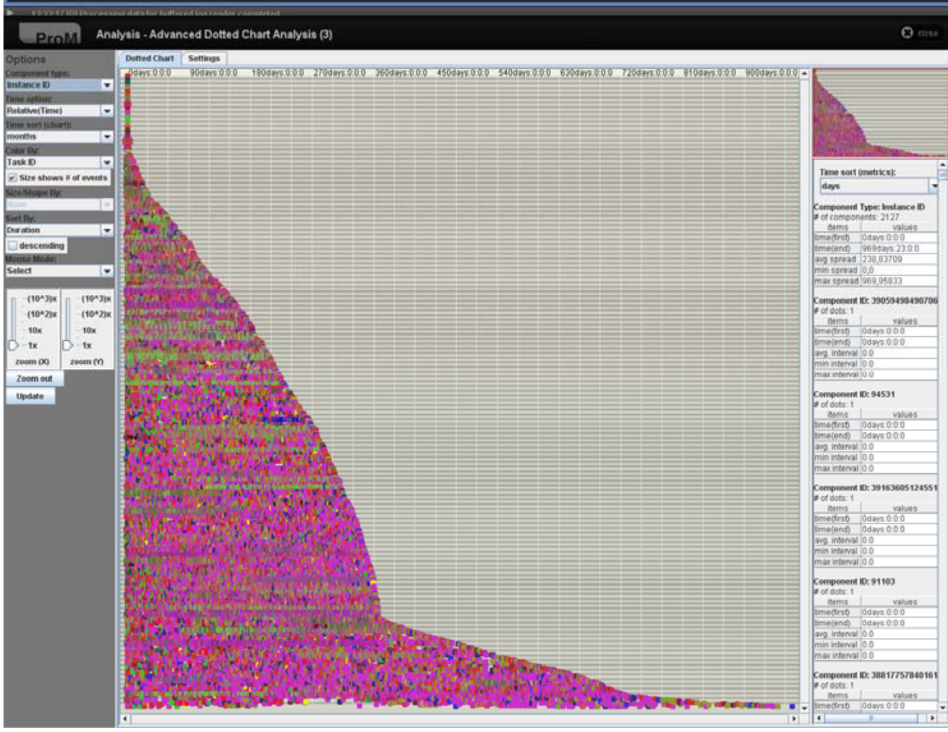
	all trajectories closed	all pervasief trajectories closed	pervasief trajectories closed ≥ 12 years old	pervasief trajectories closed < 12 years old	all trajectories closed > 5 activities	all pervasief trajectories closed > 5 activities	pervasief trajectories closed ≥ 12 years old, > 5 activities	pervasief trajectories closed < 12 years old, > 5 activities	all trajectories closed > 5 activities, < 30 days waiting time	all pervasief trajectories closed > 5 activities, < 30 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 30 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 60 days waiting time	all trajectories closed > 5 activities, < 90 days waiting time	all pervasief trajectories closed > 5 activities, < 90 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, < 90 days waiting time	pervasief trajectories closed < 12 years old, > 5 activities, < 90 days waiting time	all trajectories closed > 5 activities, ≥ 30 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 30 days waiting time	all trajectories closed > 5 activities, ≥ 90 days waiting time	all pervasief trajectories closed > 5 activities, ≥ 90 days waiting time	pervasief trajectories closed ≥ 12 years old, > 5 activities, ≥ 90 days waiting time	pervasief trajectories closed < 12 years old, > 5 activities, ≥ 90 days waiting time	all trajectories closed ≤ 5 activities	all pervasief trajectories closed ≤ 5 activities	pervasief trajectories closed ≥ 12 years old, ≤ 5 activities	pervasief trajectories closed < 12 years old, ≤ 5 activities
act_1	0,56%	0,56%	0,66%	0,45%	0,07%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,13%	0,00%	0,00%	0,00%	0,08%	0,00%	0,00%	0,00%	0,00%	0,00%	1,23%	1,51%	1,71%	1,28%
act_2	10,34%	12,68%	14,47%	10,84%	5,66%	5,99%	6,41%	5,57%	5,24%	6,38%	5,88%	4,90%	5,12%	5,11%	5,16%	5,04%	5,73%	5,95%	6,30%	6,80%	7,94%	5,95%	17,65%	24,17%	27,43%	20,51%
act_3	37,05%	37,49%	36,40%	38,60%	40,97%	45,42%	43,77%	47,04%	35,08%	46,81%	44,12%	42,16%	40,21%	46,72%	43,87%	50,42%	41,91%	45,30%	41,89%	44,22%	43,65%	44,64%	25,86%	23,87%	24,57%	23,08%
act_4	0,09%	0,11%	0,00%	0,23%	0,14%	0,18%	0,00%	0,35%	0,00%	0,00%	0,00%	0,00%	0,26%	0,37%	0,00%	0,84%	0,17%	0,19%	0,00%	0,00%	0,00%	0,00%	0,14%	0,00%	0,00%	0,00%
act_6	0,09%	0,00%	0,00%	0,00%	0,14%	0,00%	0,00%	0,00%	0,52%	0,00%	0,00%	0,00%	0,26%	0,00%	0,00%	0,00%	0,08%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
act_7	49,27%	47,94%	46,27%	49,66%	47,85%	46,48%	46,26%	46,69%	28,80%	27,66%	26,47%	44,12%	45,07%	44,16%	45,16%	42,86%	50,87%	48,18%	51,18%	48,64%	47,62%	49,40%	54,58%	50,45%	46,29%	55,13%
act_8	2,59%	1,22%	2,19%	0,23%	5,16%	1,94%	3,56%	0,35%	30,37%	19,15%	23,53%	8,82%	8,93%	3,65%	5,81%	0,84%	1,16%	0,38%	0,63%	0,34%	0,79%	0,00%	0,55%	0,00%	0,00%	0,00%
Color																										

Appendix K: Specifications client groups

All closed care trajectories

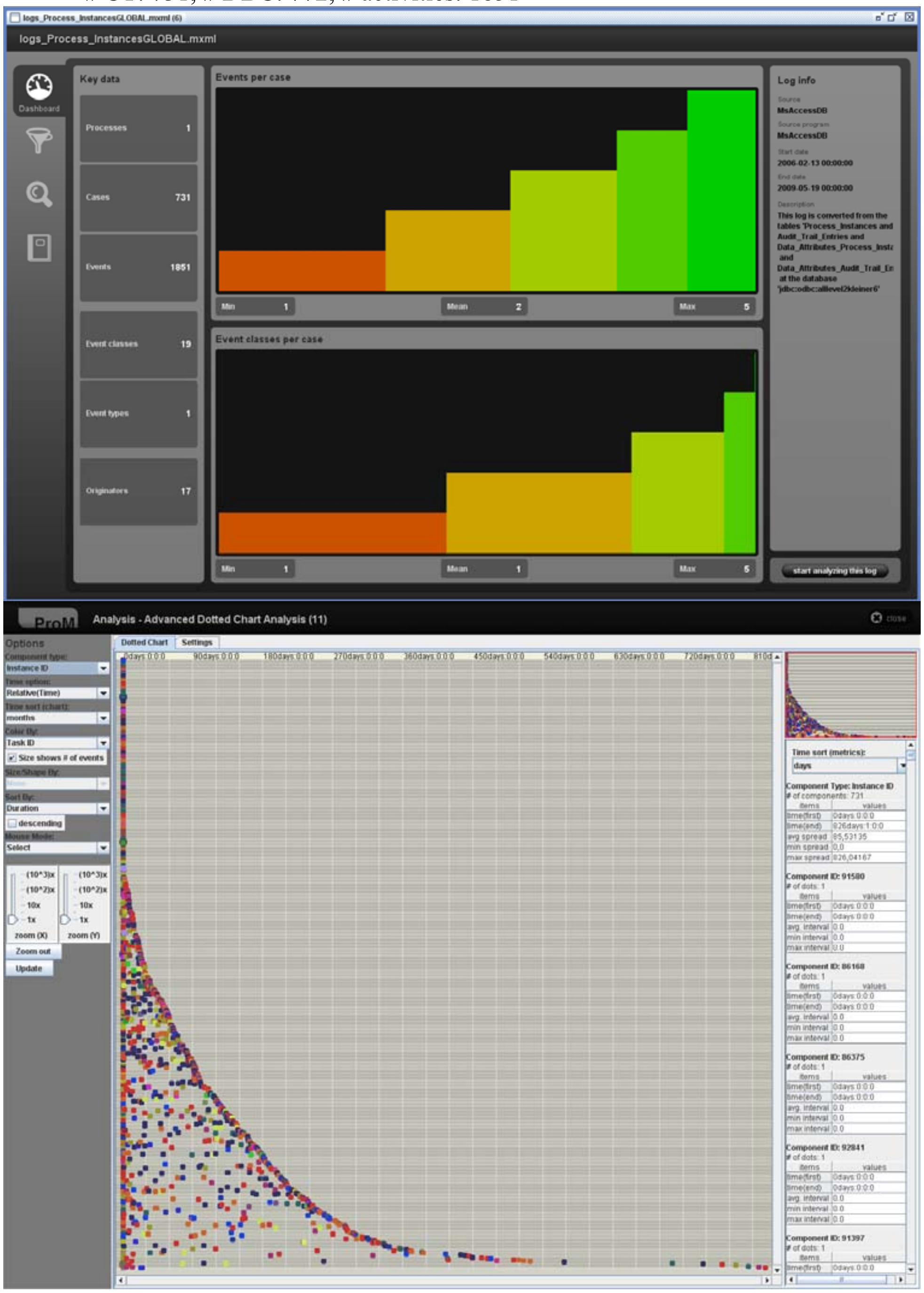
- Closed care trajectories only
- Activities level 2 and professions level 2
- Activities executed by more than 1 resource are grouped and resources are renamed as “multiple_*name level1 activity*”
- # CT: 2127, # DBC: 2515, # activities: 50351





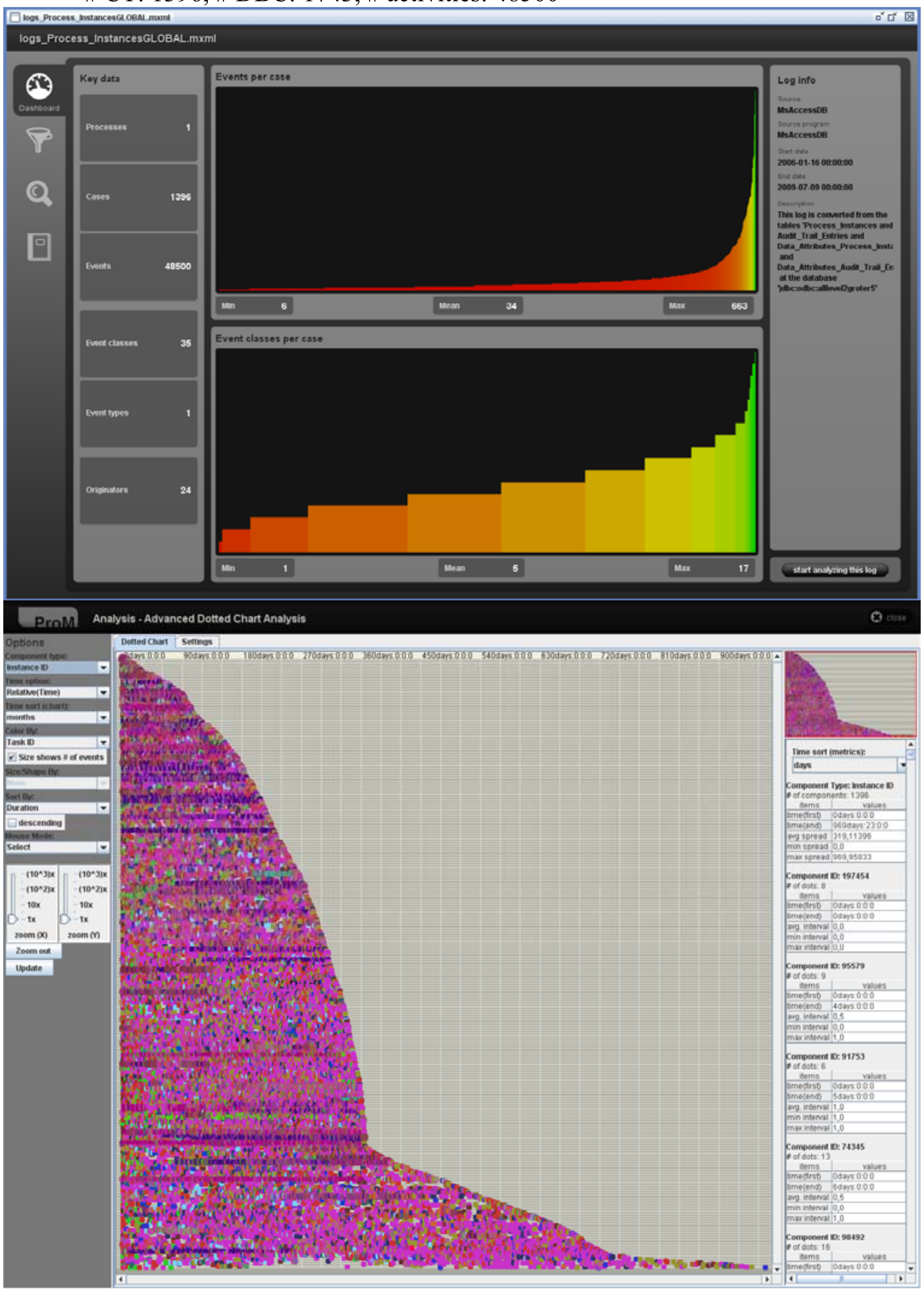
Care trajectories with 5 or less activities (rapid discharge)

- Closed care trajectories only
- Activities level 2 and professions level 2
- Activities executed by more than 1 resource are grouped and resources are renamed as “multiple_*name level1 activity*”
- # CT: 731, # DBC: 772, # activities: 1851



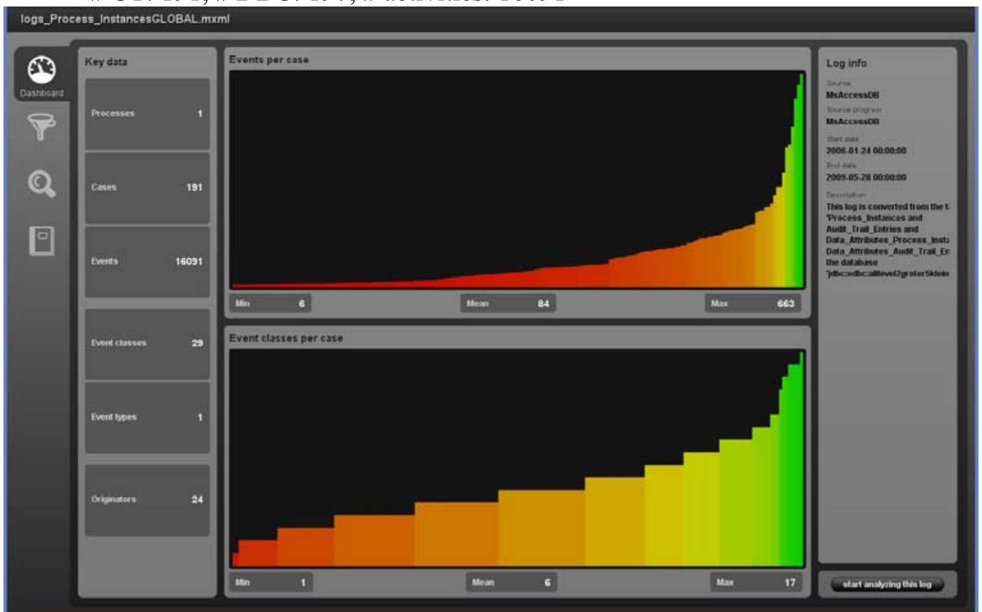
Care trajectories containing more than 5 activities (complement of rapid discharge)

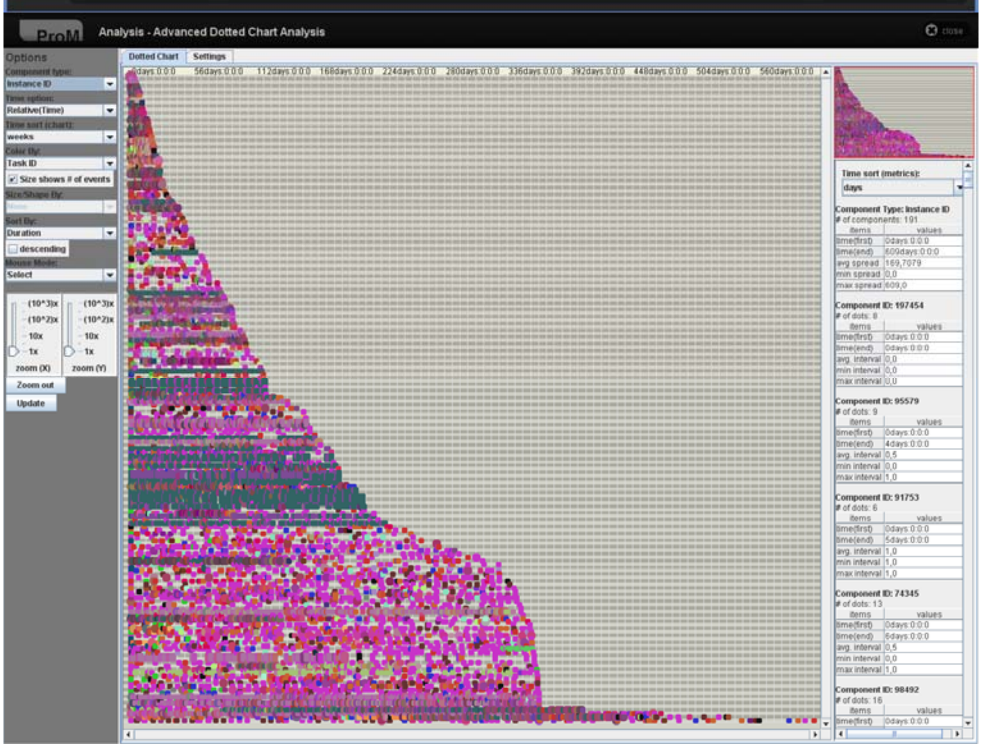
- Closed care trajectories only
- Activities level 2 and professions level 2
- Activities executed by more than 1 resource are grouped and resources are renamed as "multiple_*name level1 activity*"
- # CT: 1396, # DBC: 1743, # activities: 48500



Care trajectories with more than 5 activities and waiting times smaller than 30 days

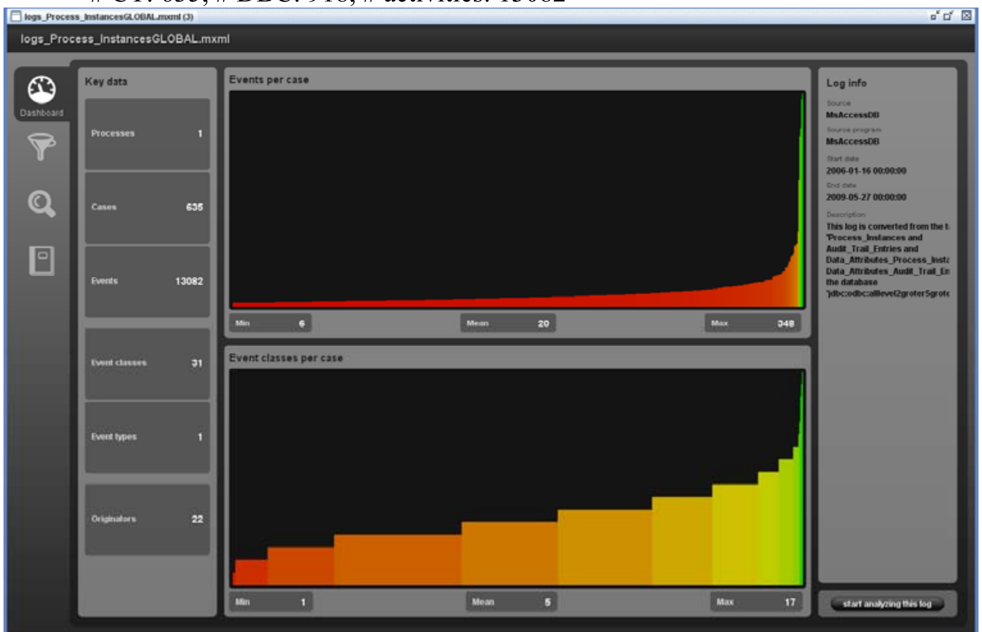
- Closed care trajectories only
- Activities level 2 and professions level 2
- Activities executed by more than 1 resource are grouped and resources are renamed as "multiple_*name level1 activity*"
- # CT: 191, # DBC: 197, # activities: 16091

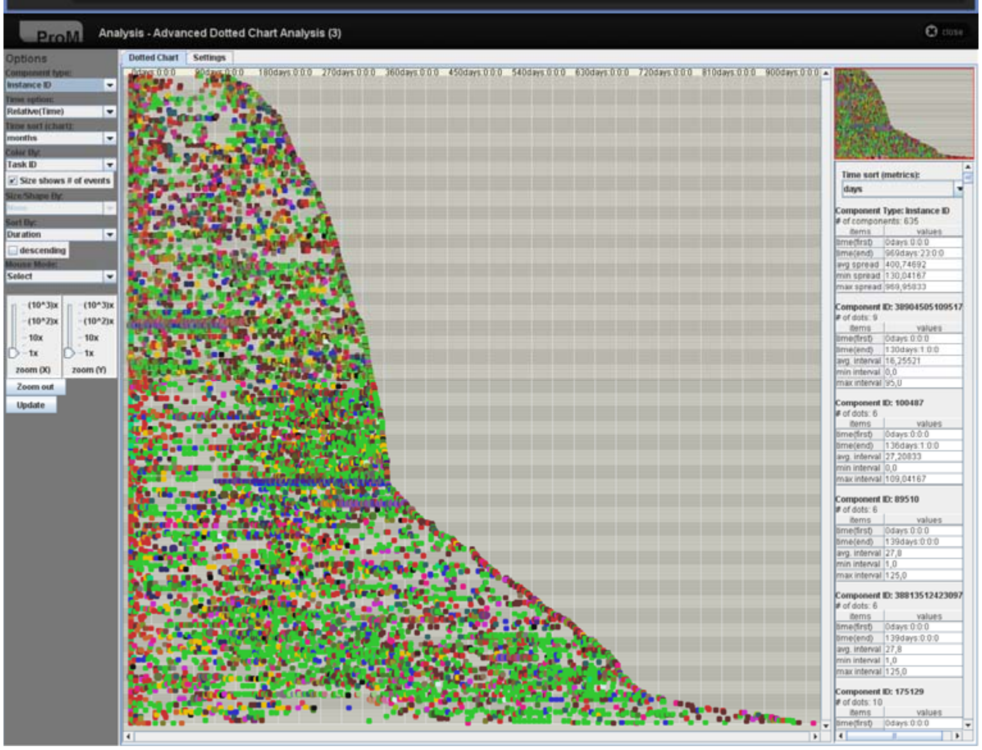




Care trajectories with more than 5 activities and at least one succession with waiting times larger than 90 days

- Closed care trajectories only
- Activities level 2 and professions level 2
- Activities executed by more than 1 resource are grouped and resources are renamed as “multiple_*name level1 activity*”
- # CT: 635, # DBC: 918, # activities: 13082





Appendix L: Presentation – Cliëntstromen in GGzE Centrum Kinderen en Jeugdpsychiatry

Inhoud

- Introductie
  - Aanleiding en doel onderzoek
  - Aankomstpatroon en doorlooptijden cliënten
- Complexiteit van zorgprocessen K&J
- Proces karakteristieken
  - Overview van activiteiten en medewerkers
  - Bottlenecks
  - Procespatronen
  - Cliëntgroepen
- Vragen / discussie

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Introductie I

- Aanleiding onderzoek:
  - Hoge wachttijden voor cliënten
  - Weinig inzicht in de flow van cliënten door het behandeltraject.
- Doel onderzoek:
  - Kwantitatieve analyse van cliëntstromen binnen GGzE Centrum Kinderen en Jeugdpsychiatrie.
  - Inzicht verkrijgen in processen en verlagen van doorlooptijden en wachttijden.
- Scope:
  - Cliëntstromen (zorgtrajecten in DBC data).

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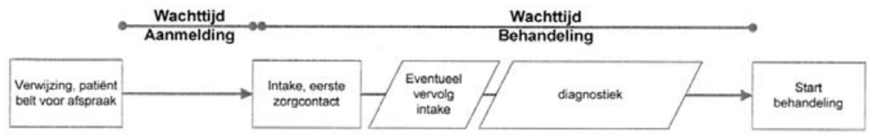
Introductie II

- **Zorgproces**



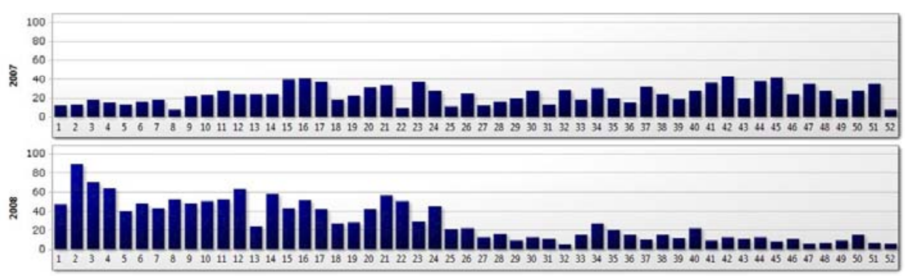
Schematisch weergave wachttijden ggz

(bron: http://www.ggznederland.nl/scrivo/asset.php?id=289315)

- **Wachttijden veroorzaakt door variantie in:**
  - **Aankomst proces van cliënten**
  - **Proces tijden (intake, screening, diagnose en behandeling)**
  - **Proces routing!**

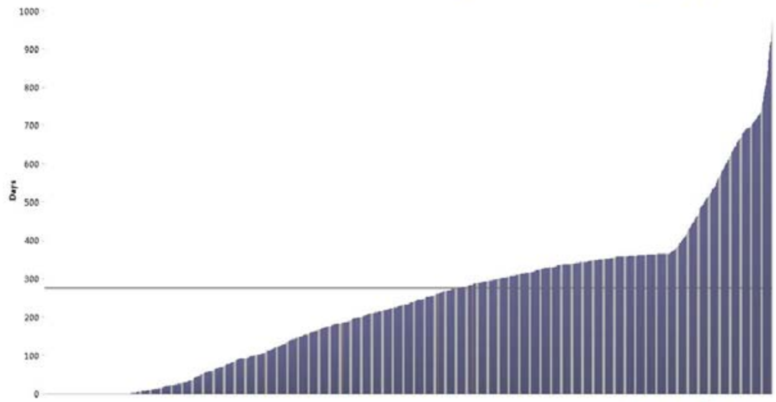
Introductie III

- **Aankomstpatroon cliënten centrum K&J**
  - **Aantal startdatums van zorgtrajecten per week in 2007 en 2008:**



Introductie IV

- **Doorlooptijden cliënten centrum K&J**
  - **Van start- tot einddatum van gesloten zorgtrajecten:**



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Data analyse

- **Data analyse gebaseerd op DBC data:**
  - **Informatie over: cliënt, zorgtraject, DBC traject, diagnoses, activiteiten, dagbesteding en verblijf**
  - **DBC data van november 2007 tot november 2009.**
    - **Eerste startdatum: 31 oktober 2005.**
    - **Laatste einddatum: 29 december 2009.**
  - **Aantallen:**
    - **Cliënten (aankomst): 3511**
    - **Zorgtrajecten (geopend): 3607**
    - **Zorgtrajecten (gesloten): 2127**

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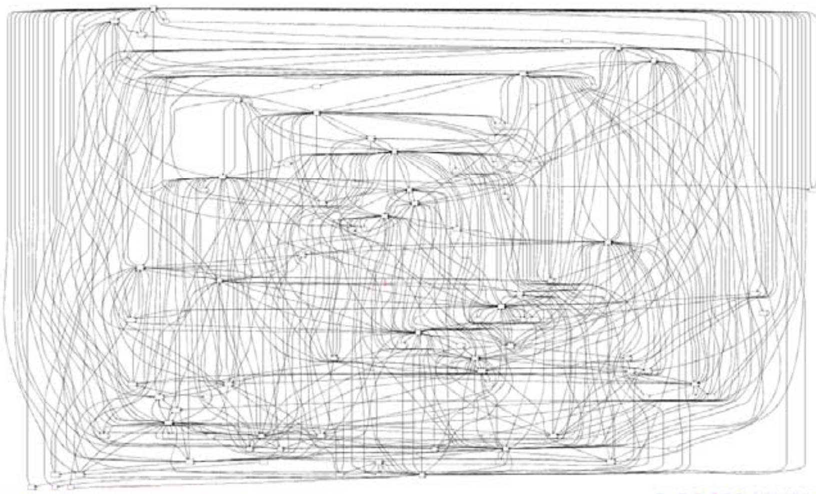
Complexiteit van zorgprocessen K&J I

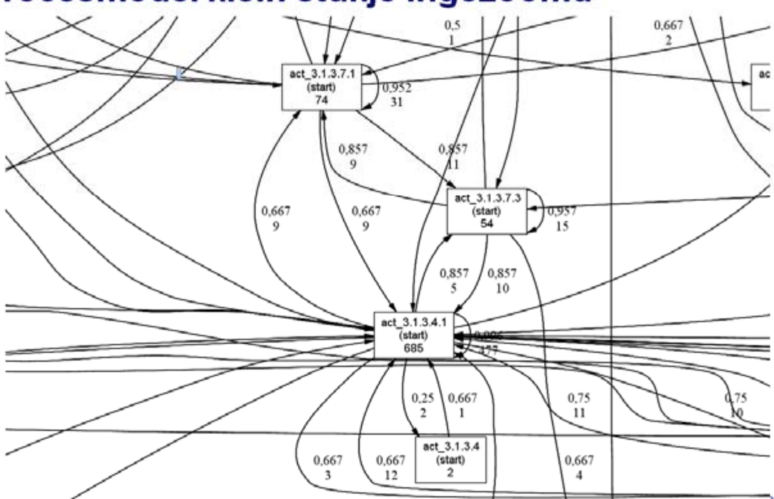
- **Procesmodel *alle* processen centrum K&J**



(proces model verkregen met Heuristic miner ProM)

Complexiteit van zorgprocessen K&J II

- **Procesmodel klein stukje ingezoomd**



(proces model verkregen met Heuristic miner ProM)

Complexiteit van zorgprocessen K&J III

- **Conclusie:**
  - **Typisch spaghetti model**
  - **Processen zijn complex en onoverzichtelijk**
- **Hoe kunnen we meer inzicht verkrijgen?**
  - **Systematische benadering d.m.v. Visual Analytics**
  - **Processen *filteren* op bijvoorbeeld: primaire diagnoses, ambulant / klinisch, …**
  - **Activiteiten en medewerkers analyseren vanuit een hoger niveau**

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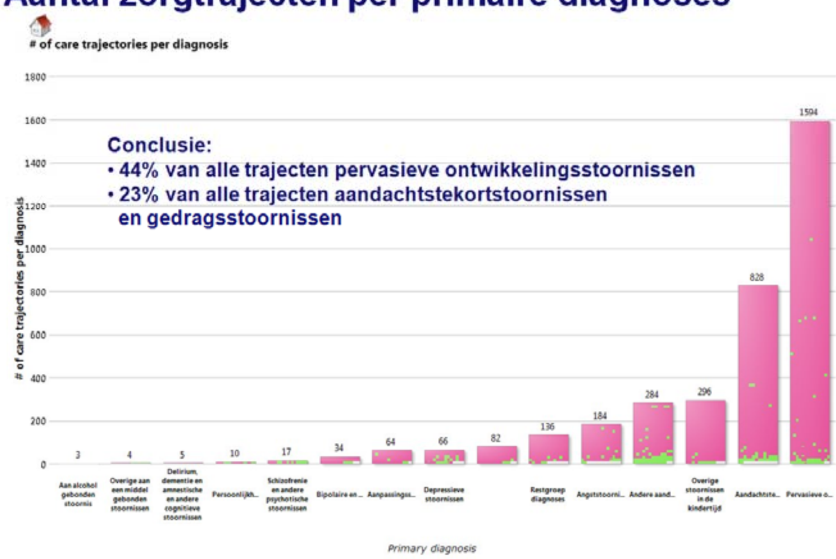
Proces karakteristieken – overview I

Aantal zorgtrajecten per primaire diagnoses



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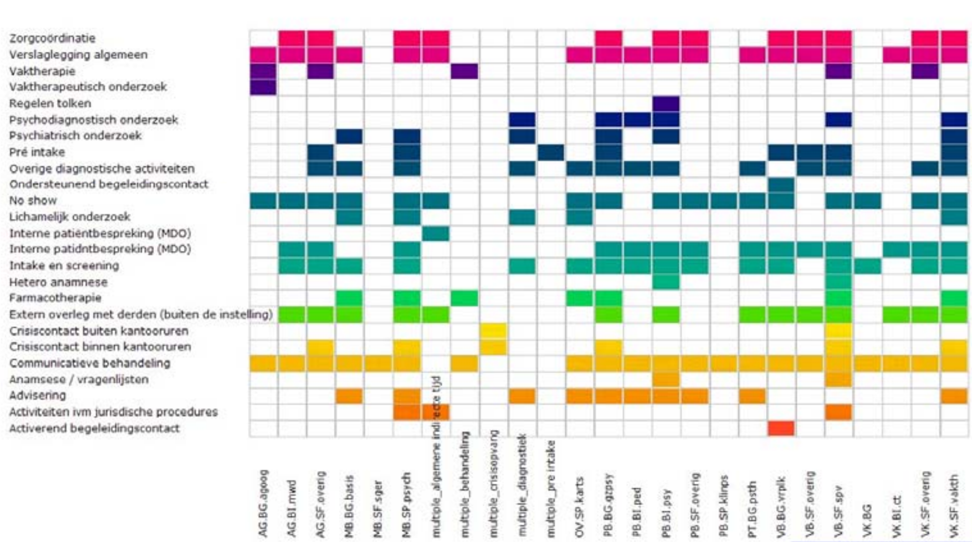
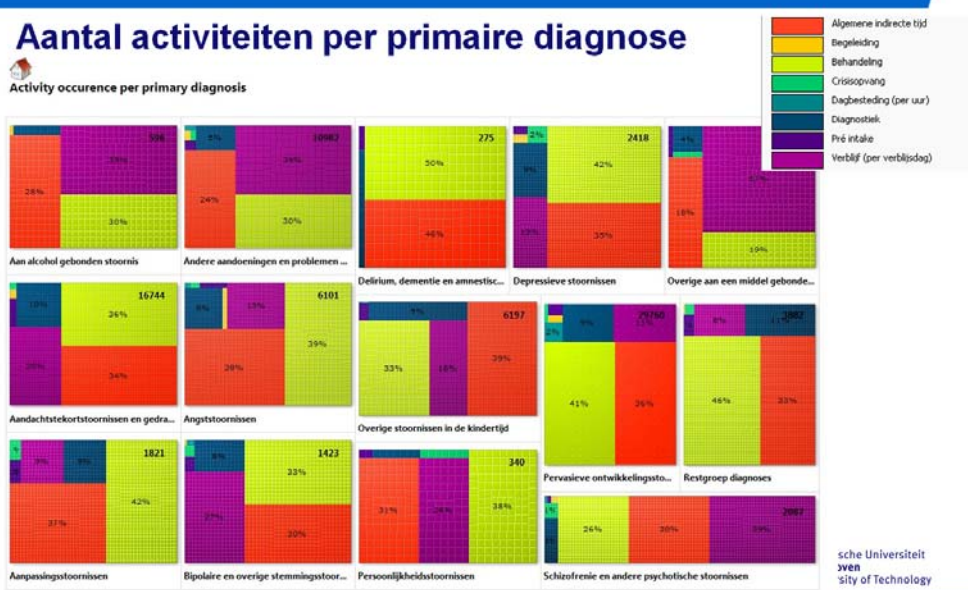
Proces karakteristieken – overview II

Activiteiten en hun uitvoerders



Proces karakteristieken – overview III

Aantal activiteiten per primaire diagnose



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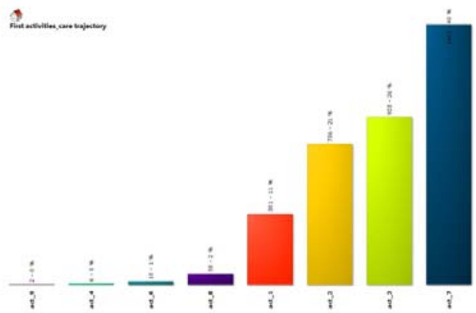
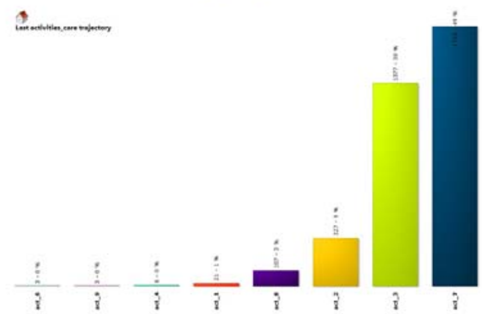
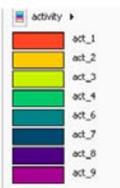
Proces karakteristieken – overview IV

Eerste activiteiten van een zorgtraject



Laatste activiteiten van een zorgtraject

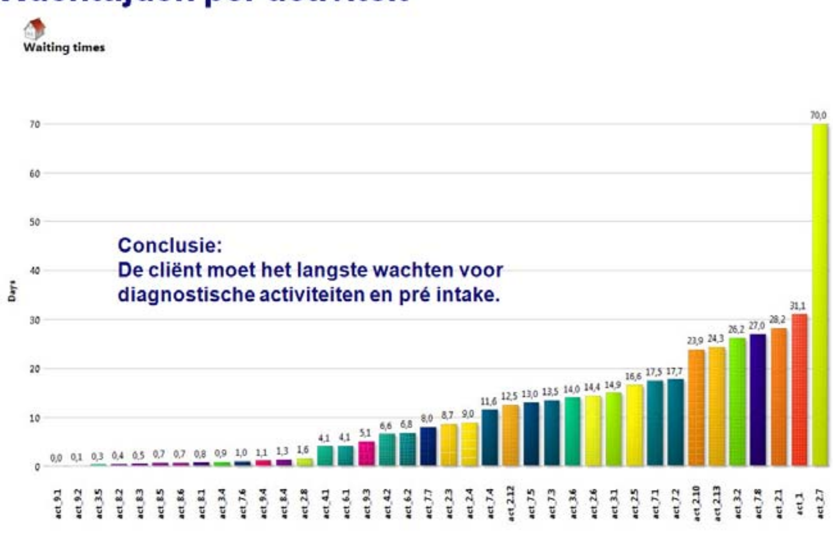




Opvallend:
- Vaak wordt een traject begonnen en geëindigd met overleg.
- De eerste activiteit is vaker een behandeling dan pré intake of diagnostiek.

Bottlenecks I

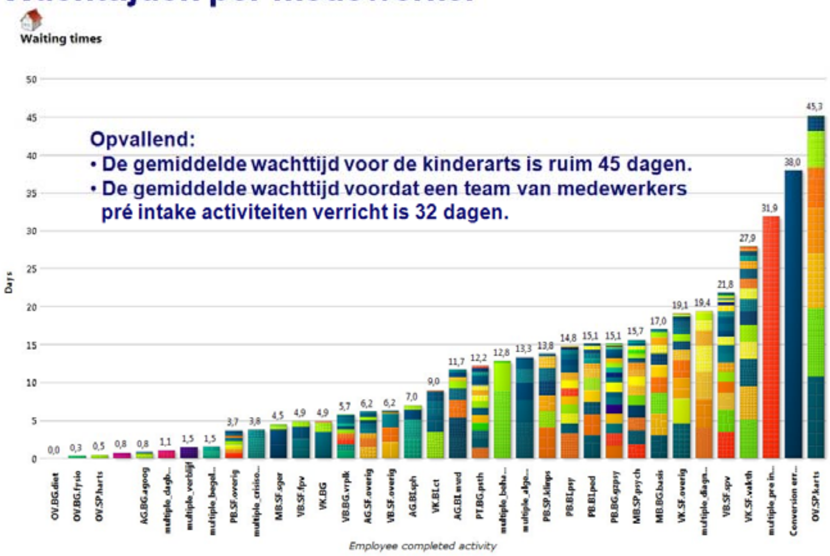
Wachttijden per activiteit



Conclusie:
De cliënt moet het langste wachten voor diagnostische activiteiten en pré intake.

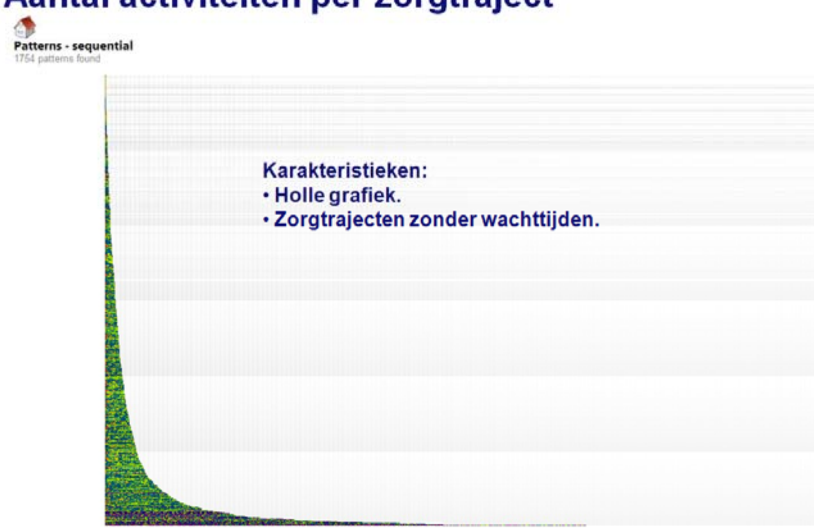
Bottlenecks II

Wachttijden per medewerker



Procespatronen I

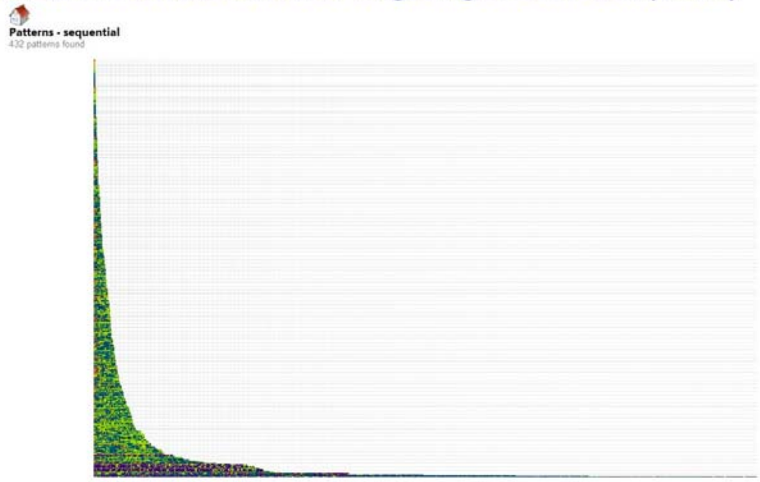
Aantal activiteiten per zorgtraject



Procespatronen II

Aantal activiteiten per zorgtraject

Aandachtstekortstoornissen en gedragsstoornissen (ADHD)



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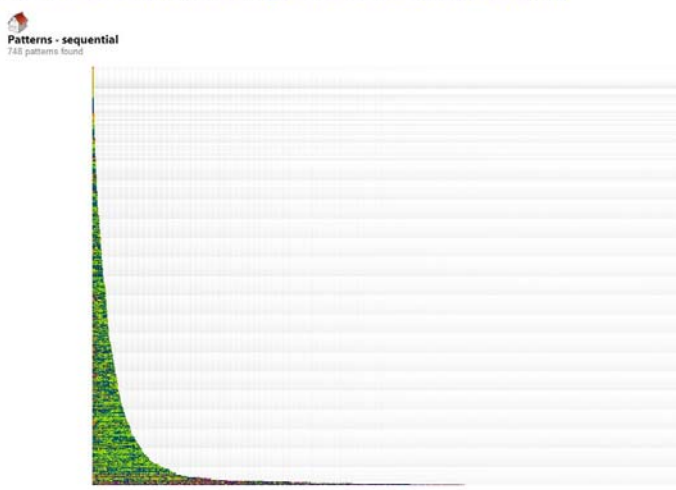
Procespatronen III

Aantal activiteiten per zorgtraject

Pervasieve ontwikkelingsstoornissen (autisme)



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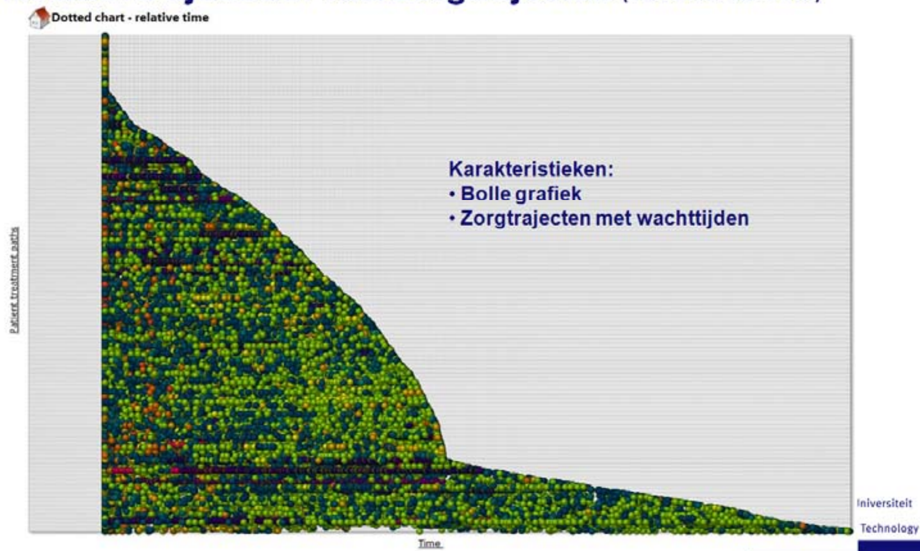
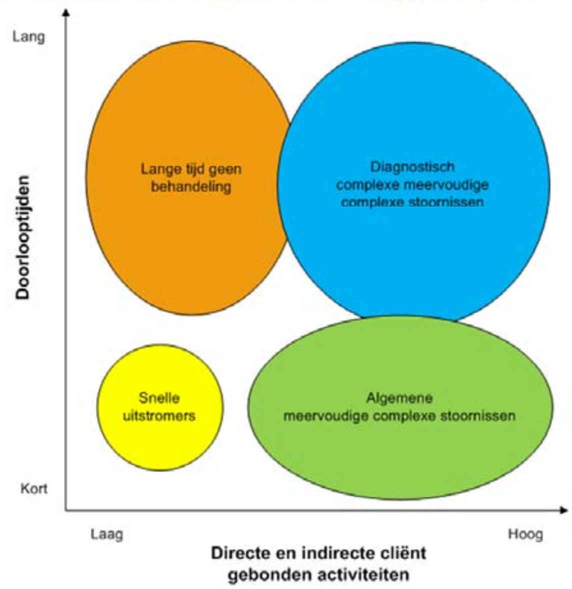
Procespatronen IV

Relatieve tijdsduur van zorgtrajecten (van start tot eind)



Procespatronen V

Schematische weergave cliëntgroepen



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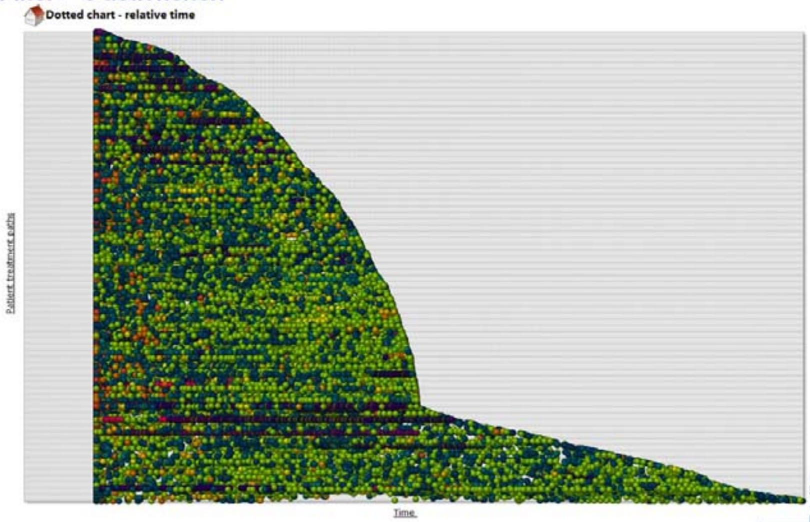
Procespatronen VI

Relatieve tijdsduur van zorgtrajecten (van start tot eind)

Filter > 5 activiteiten



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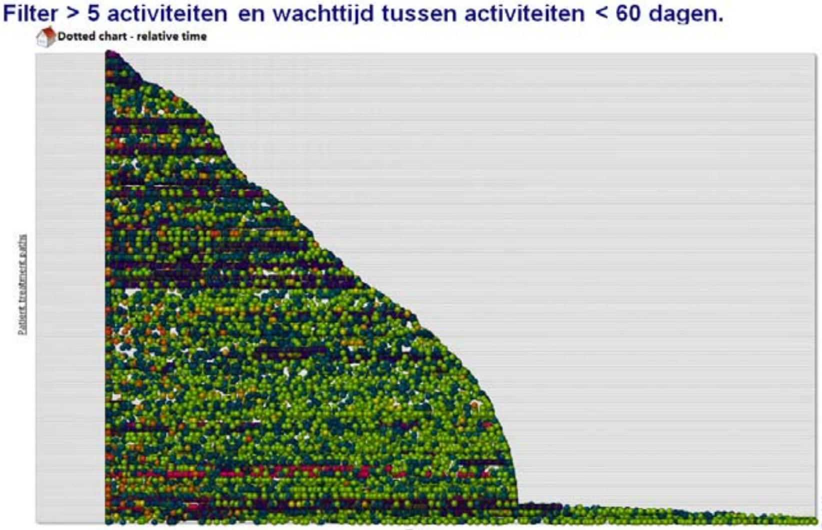
Procespatronen VII

Relatieve tijdsduur van zorgtrajecten (van start tot eind)

Filter > 5 activiteiten en wachttijd tussen activiteiten < 60 dagen.



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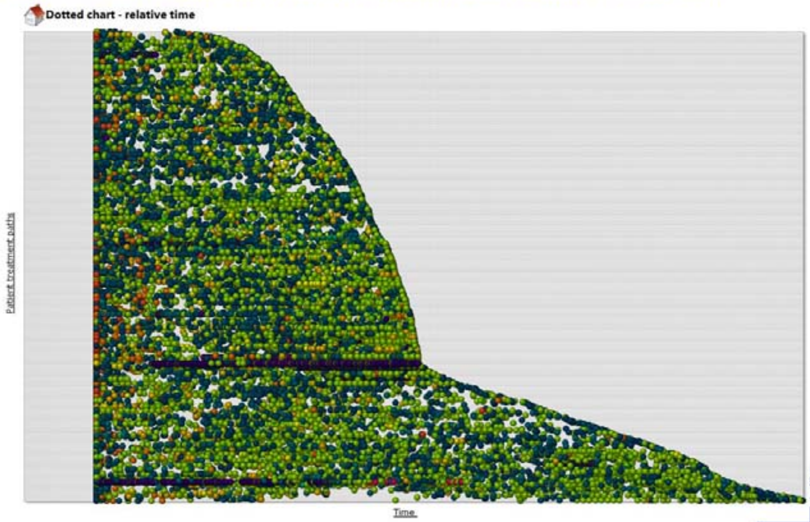
Procespatronen VIII

Relatieve tijdsduur van zorgtrajecten (van start tot eind)

Filter > 5 activiteiten en wachttijd tussen activiteiten > 60 dagen.



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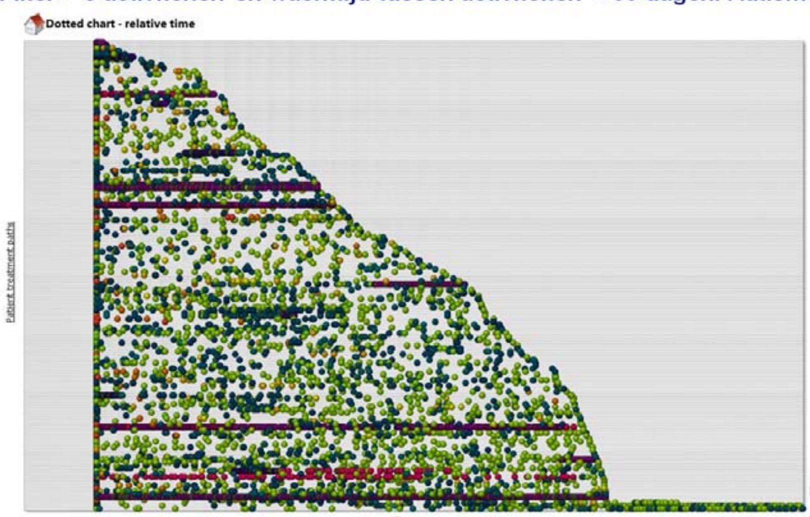
Procespatronen IX

Relatieve tijdsduur van zorgtrajecten (van start tot eind)

Filter > 5 activiteiten en wachttijd tussen activiteiten < 60 dagen. Autisme



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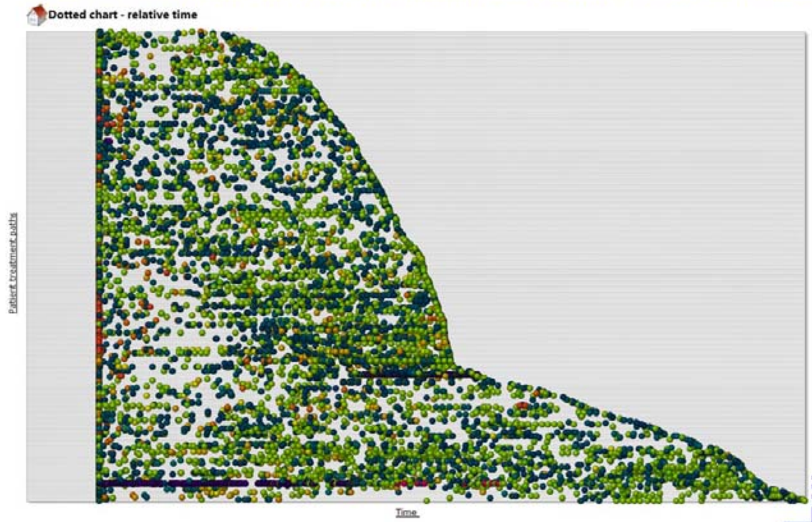
Procespatronen X

Relatieve tijdsduur van zorgtrajecten (van start tot eind)

Filter > 5 activiteiten en wachttijd tussen activiteiten > 60 dagen. Autisme

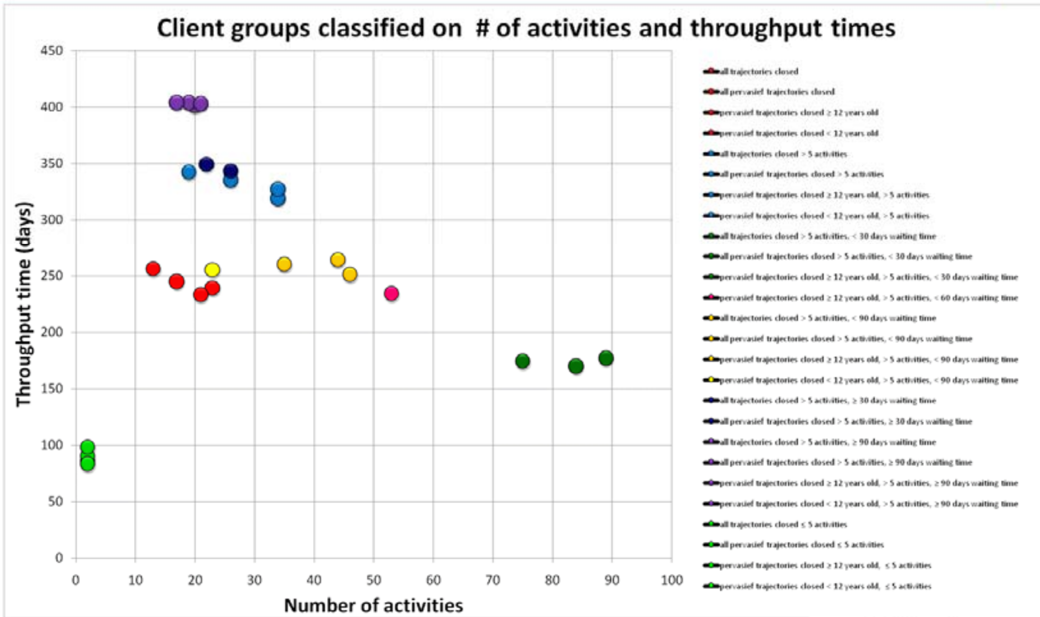


Cliëntgroepen I

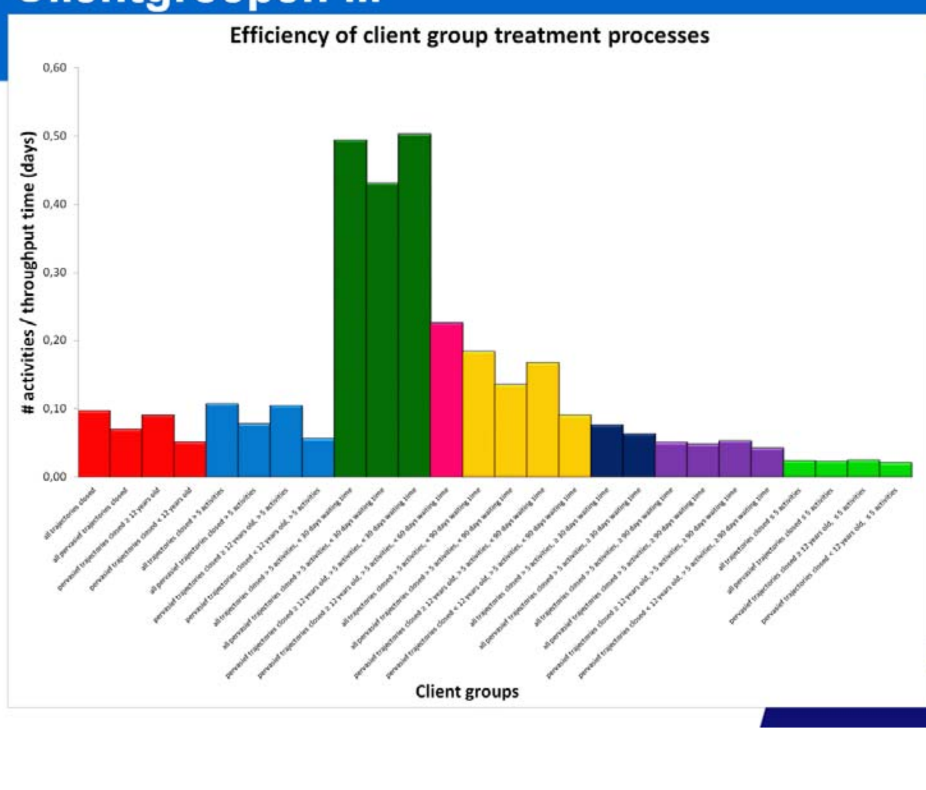
Aanvullende analyse cliëntgroepen

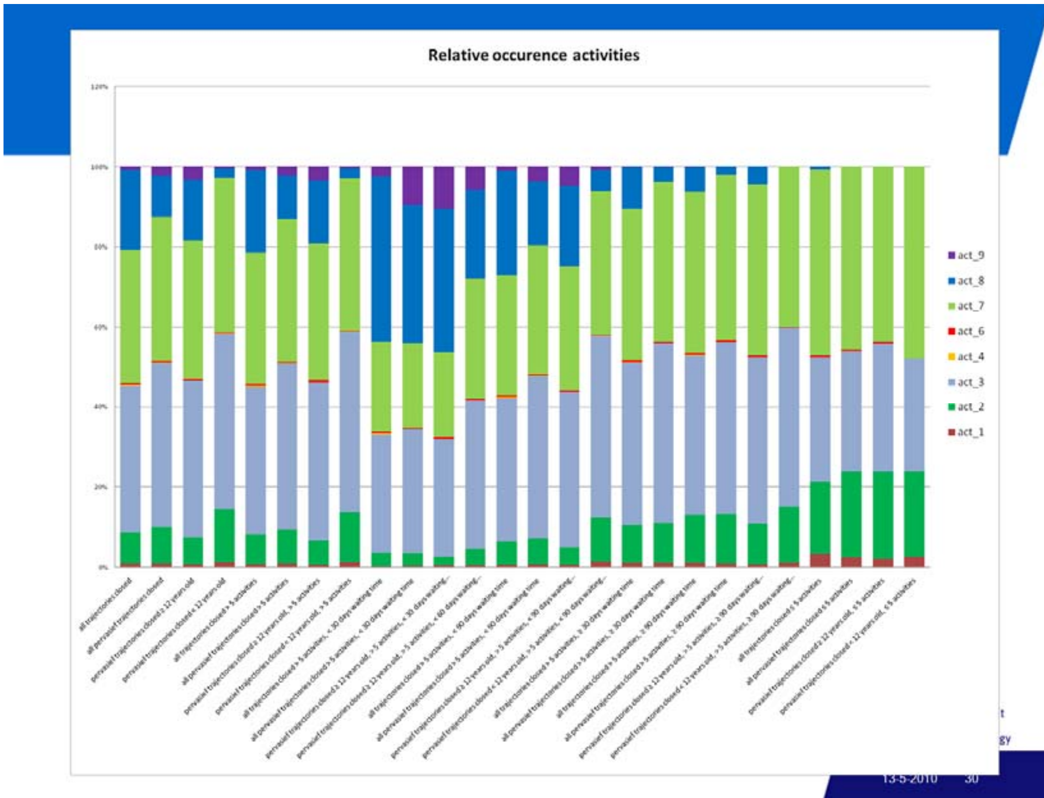
		All	Pervasief		
			All	≥ 12	< 12
All		# CT 2127 # act 50351	# CT 899 # act 16112	# CT 456 # act 10027	# CT 443 # act 6085
> dan 5 activiteiten	All	# CT 1396 # act 48500	# CT 568 # act 15330	# CT 281 # act 9626	# CT 287 # act 5704
	< 30 dg w.t.	# CT 191 # act 19091	# CT 47 # act 3566	# CT 34 # act 3029	
	< 60 dg w.t.			# CT 102 # act 5506	
	< 90 dg w.t.	# CT 761 # act 35418	# CT 274 # act 9674	# CT 155 # act 6934	# CT 119 # act 2740
	≥ 30 dg w.t.	# CT 1205 # act 32409	# CT 521 # act 11764		
	≥ 90 dg w.t.	# CT 635 # act 13082	# CT 294 # act 5656	# CT 126 # act 2692	# CT 168 # act 2964
≤ dan 5 activiteiten		# CT 731 # act 1851	# CT 331 # act 782	# CT 175 # act 401	# CT 156 # act 381

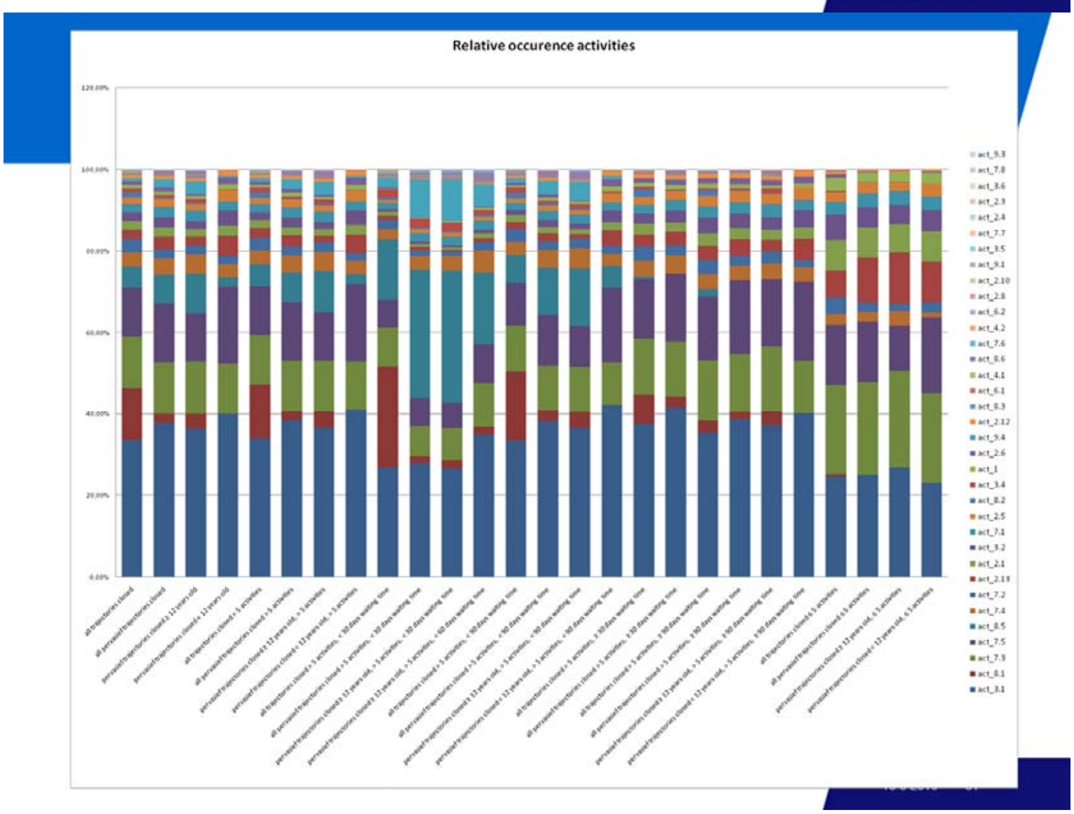
Cliëntgroepen II

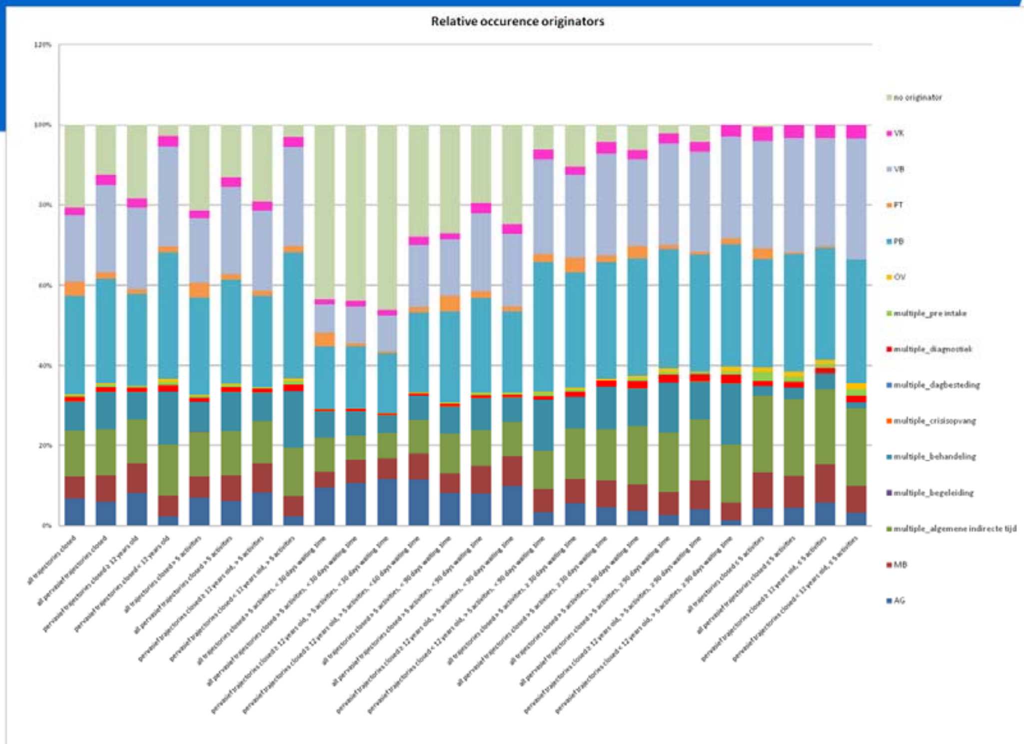


Cliëntgroepen III




Relative occurence activities
120%
100%
80%
60%
40%
20%
0%
act_9
act_8
act_7
act_6
act_4
act_3
act_2
act_1
13-5-2010
30


Relative occurence activities
120,00%
100,00%
80,00%
60,00%
40,00%
20,00%
0,00%



Vragen / discussie

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