CareTopics

Designing a dashboard development methodology for heterogeneous stakeholders in Dutch nursing homes

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Abstract

Data visualization is very useful for humans to read and understand data. Dashboards, a data visualization tool have a huge potential to be of high value to the healthcare sector. A dashboard development methodology, applicable in the healthcare sector has not been identified in the current literature. This research proposes such a methodology and identify challenges and opportunities, which might emerge during dashboard development in healthcare settings. This research was specifically focused on nursing homes in the Netherlands. In many Dutch nursing homes however, it was found that data quality and reliability regarding healthcare quality is currently not sufficient to make reliable data analysis.

Contents

List of Abbreviations

DDMiH Dashboard Development Methodology in Healthcare.

DSR Design Science Research.

EHR Electronic Health Record.

GT Grounded Theory.

KPI Key Performance Indicator.

ODDM Orlando's Dashboard Development Methodology.

PM Performance Measures.

QFNH Quality Framework for nursing homes.

QS Quality Safety.

SUS System Usability Scale.

TURF Tasks, Users, Representations and Functions.

UMUX Usability Metric for User Experience.

1 Introduction

Humans perceive most information in life in a visual form and rely on pattern recognition to process information. It is, therefore, preferable to use visualization tools for understanding a problem and assessing available data, especially in the case of large data-sets. [2] According to experts and the literature, the visualization of data is very useful for humans to read and understand data.[2][3][4][5][6] As said by Professor Ben Schneiderman of UMIACS: "Visualization gives you answers to questions you didn't know you had." Dashboards are a tool for visualizing data and can help to get valuable insights from this data, which would not be possible otherwise. Subsequently, appropriate actions can be taken by the management to improve and monitor performance in real or near real-time. Clinical dashboards are a form of health information technology that use data visualization techniques (graphical displays that summarize data) to provide feedback to health care professionals on their performance compared to quality metrics. [4] Compared to other forms of feedback, clinical dashboards have the potential to provide feedback in real time when clinicians are engaged in care activities, rather than a retrospective summary of performance.[6] Healthcare organizations are increasingly faced with the challenge of providing high quality services in affordable cost. As probably heard many times before, the increase of life expectancy[7] and consistently low birthrates in the Netherlands[8], results in a much older population structure in the near future. This has the effect that a growing part of the population will need nursing care, while a decreasing working population has to bear the workload.[9] At the same time there is increasingly more attention for the quality of care given at nursing homes. Valid, reliable, and timely data about nursing facility residents and the care they receive are fundamental to all strategies for monitoring and improving quality of care.[10] Multiple countries, including the Netherlands are therefore obligating nursing homes with the delivery of annual healthcare performance and quality data. [11][12][13] The measuring and reporting of quality indicators now still involves a lot of manual work like questioning clients, their family and personnel. Also counting incidents in the client files such as the amount and degree of pressure ulcers and medication errors are often done by hand. Even-though the intentions are good (improving quality of nursing care), these data obligations increase the administrative burden and therefore the workload on an already increasingly heavy pressurized sector. To reduce the workload on nursing home personnel, it would be desirable to automate some of the tasks they have to do, which are not affiliated to direct care-taking. While the data seems to be there, although often inconsistent and scattered out on multiple databases, this data is now rarely used in nursing homes to create systems that generate insightful information about quality performance from this pile of data. Effective management and improving performance of such challenging systems require identification and optimization of multiple variables. So, static performance reporting systems are not able to completely satisfy healthcare managers' decision support needs and more interactive tools must be developed to transmit, organize, analyze, and display performance data in real or near real-time. [6] Studies show that it is challenging for healthcare organisations to develop and prioritise useful dashboard content due to differing needs for specification. [14] Every person has aspects that differentiate them from another person. Experiences, personality and cognitive abilities influence a person's approach to solving a task and their understanding of a problem domain. [15] In cognitive psychology, researchers have shown that such individual differences can significantly impact a user's dexterity using an interface or a tool to solve problems. Users of data visualization tools differ greatly in experiences, backgrounds, personalities and cognitive abilities. Cognitive factors such as perceptual abilities, spatial abilities, verbal ability, and working-memory capacity also vary substantially between individuals and can affect reasoning in many ways. In particular, perceptual and spatial abilities have been shown to affect how well users perform different tasks in a visualization system. Despite these facts data visualization tools, like much other software, continue to be designed and developed for a single ideal user. [15] Multiple studies have been conducted regarding dashboards in healthcare organisations, which mention a vast amount of challenges and opportunities faced during the development, implementation and usage of (quality) performance dashboards in the healthcare sector. See Appendix B. Even though multiple dashboard are already developed and implemented, no clear methodology has been described which take into account these challenges and opportunities which emerge during dashboard development, implementation and usage in the healthcare sector. The focus of this study is the development of a dashboard development methodology which takes into account the challenges and opportunities that emerge when developing, implementing and using dashboards in a healthcare setting. Performance Measures (PM) that dashboards capture and display are just as important as their other design features, as dashboards will be useful only if the data they provide are valuable. As the most valuable content of dashboards, Key Performance Indicator (KPI)'s (that are performance measures in key areas of a service) provide the foundation

for performance measurement, and help to measure progress against predefined targets or benchmarks, spend more time on critical activities, and compare performance across the organization. Well-defined KPI's exactly indicate where corrective actions should be adopted. So, Key issues that need to be addressed regarding KPI's are mainly focused on their selection and development: Focusing on few measures can potentially lead to ignore other important performance areas or functional and environmental features. Furthermore, isolated measures, developed separately, will not provide a comprehensive, consistent and fair assessment of performance. Establishing a well categorized (not necessarily balanced) set of KPI's initially requires a well-defined methodology and considering different dimensions of performance. [6] The structure of this research is as following. First, the goal of this research will be made clear and afterwards, the search strategy to answer those questions will be elaborated on. Then the method of how these results from the literature research will answer the questions of this research will be explained. The result will be applied to a use case and this use case will be analysed to come to a conclusion.

2 Scope, research goal & research questions

The goal of this research is to adapt existing dashboard development methodologies into a methodology which is applicable in the healthcare sector, specifically inside nursing homes in the Netherlands, to increase healthcare quality. This research can be divided into 3 parts. First a literature research will be conducted to find which dashboard development methodologies already exist, to which extent they can be used in healthcare settings and to see what difficulties and opportunities developers may encounter according to the literature. Secondly, the results from the literature research will be applied to find the challenges and opportunities of dashboards in healthcare settings in practice. Thirdly, the literature research combined with practical experiences from the use-case will be analysed to see to which extent quality dashboards can increase healthcare quality.

- **RQ1:** Which dashboard development methodologies applicable in healthcare settings exists in the literature?
- **RQ2:** Which challenges and opportunities emerge during dashboard developments in the healthcare sector?
- **RQ3:** Can quality dashboards be effectively implemented in Dutch nursing homes?

During the literature research of existing dashboard development methodologies and applications of dashboards in nursing homes and hospitals, more questions were raised which can be divided into 3 main fields of interest. See Figure 1 for an overview.

- **Quality of care**
  What is quality of care? How to improve quality of care? What are the KPI's of quality of care?
- **Data selection/collection**
  Which data is needed? Is this data already available? Where is this data stored? How much effort is needed to convert the data into a useful format? Is it worth the effort or are there easier/better manners to monitor or improve the same KPI?
- **Data visualisation**

Project management and adoption/acceptance of performance measurement systems in healthcare are important aspects that need to be kept in mind during the whole process of dashboard development in the healthcare sector, but are outside of the scope of this research.

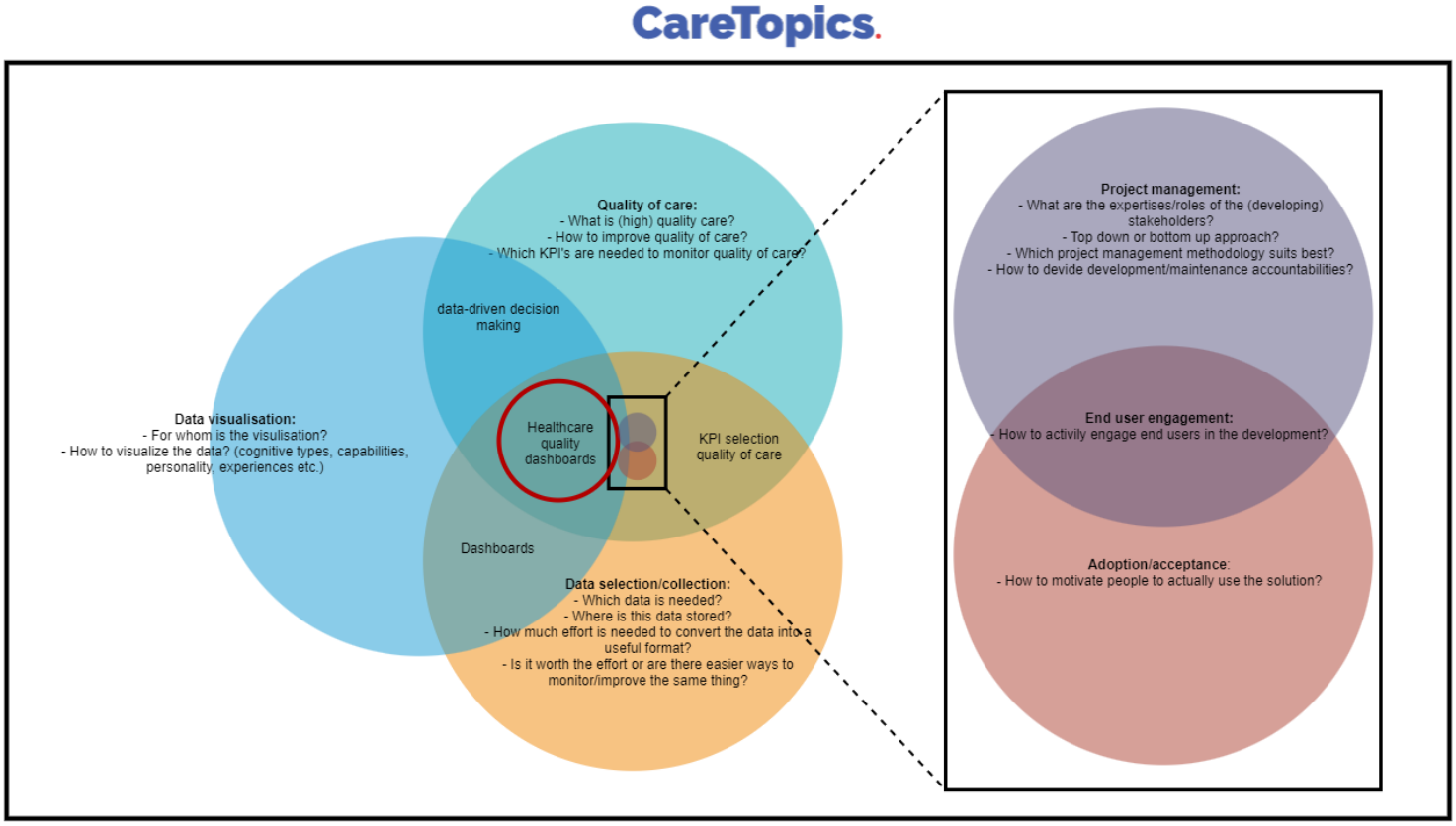

Figure 1: Subjects and questions Caretopics covers/raises

3 Search strategy

To conduct the literature review, multiple methods have been used. Scopus has been used to start the literature study, reinforced with snowballing from the found literature and the references from the Dutch quality framework for nursing homes. [12] At the very beginning of the project the goal and questions regarding to Caretopics seemed pretty clear, but turned out to be less clear later on. This was due to the fact that Infotopics and Adcase wanted to improve quality of care inside nursing homes. They aim to accomplish this by developing a quality monitoring system, which enables end-users to make more data driven decisions. The goal of the first search iteration was to find a dashboard development methodology/strategy suitable for CareTopics.

3.1 First search iteration

The research question which started this research was: How to create a dashboard which enables nursing homes to make more data-driven decisions? To answer this question a literature research was conducted to get to know where the literature stands regarding to dashboard development inside nursing homes. The literature research was conducted through Scopus. The first search term used was: "Dashboard AND Development AND nursing AND homes". This unfortunately only returned 5 hits. Either the search term was too specific, excluding relevant papers or the literature is not very advanced on the subject of dashboard development inside nursing homes. To investigate this further, the search term was made more extensive to cover for the fact that relevant articles may use synonyms for search terms like: "nursing homes" and "dashboards". Nursing homes for example has multiple synonyms like: "residential care" and "elderly care". Dash-boarding for example is a tool for data visualization and relevant papers may not talk about dashboards specifically, but may contain useful insights on data visualization. Also the American and British spelling is taken into account for the word "visualization", as it can also be spelled as "visualisation". The search term: "Dashboard AND Development AND nursing AND homes" eventually became: "Dashboard OR (data AND (visualisation OR visualization)) AND development AND ((nursing AND home) OR (elderly AND home) OR (residential AND care))", which returned 34 hits. Of these 34 hits, only 1 was actually about the development of a performance measurement system, but this paper dated from 2000. This is considered too old for this subject, since big data is only winning popularity since approximately 2012, as can be seen in Figure 2 from a paper of Dash, S. et al.[16] All articles which are published before 2011 are rejected for this reason.

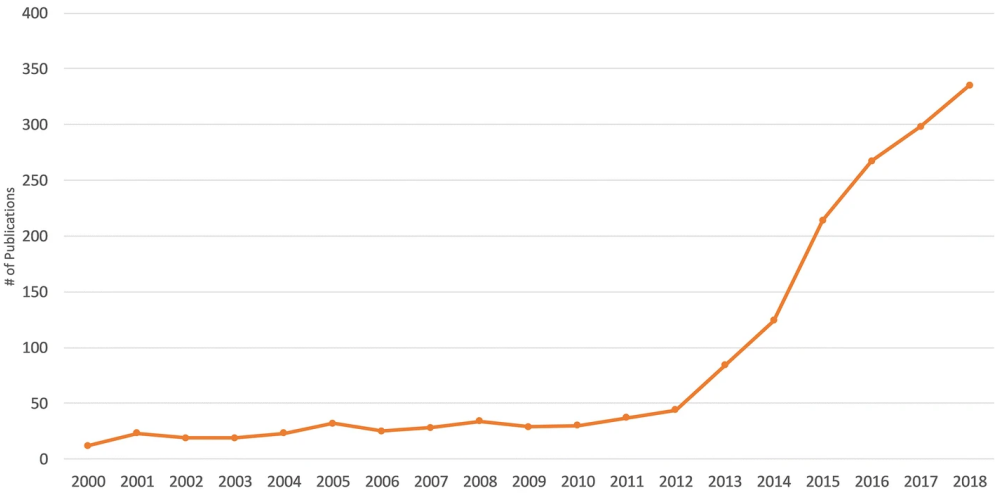

Figure 2: # of publications about big data – Dash. S. et al.[16]

3.2 Second iteration

While the first search iteration did not produce any useful articles, there can be concluded that there is a gap in the literature which merges dashboard development and nursing homes or even the healthcare sector in general. The initial idea to extract a dashboard development methodology from the literature, turned out to be impossible as it does not exists. The literature study was thus expanded to see where literature stands on the secluded topics of dashboard development and

quality monitoring inside of nursing homes. This way, the dashboard development methodology for CareTopics could be created by merging the knowledge from the secluded topics. Again like in the first iteration, Scopus was used to conduct the search and synonyms or spelling differences are accounted for. The second search term used was: "information AND systems AND quality AND monitoring AND ((elderly AND care) OR (nursing AND homes) OR (residential AND care))" and aims to find relevant papers for quality monitoring inside of nursing homes. The search term returned 452 results. To find relevant papers regarding to dashboard development or data visualization, the following search term was used: "Dashboard OR (data AND (visualisation OR visualization)) AND ((elderly AND care) OR (nursing AND homes) OR (residential AND care))" and returned 250 hits. A total of 736 records were found and 586 unrelated titles and duplicates were removed, leaving a total of 236 abstracts to screen. Of these 236 articles, 116 were assessed for eligibility. Reasons to reject a certain article were an article being too specific on a particular healthcare problem, such as ulcer wounds, an article being published more than 10 years ago and the article not having enough focus on dashboards and data visualisation or healthcare. While the combination of these two was identified as a gap in the literature, Grounded Theory (GT) is used to identify the concepts of selected articles, categorize them and create a merged dashboard development strategy which is applicable in the context of Caretopics. A mind map overview of all the fields which Caretopics covers and the questions raised during the literature research, can be found in Figure 1.

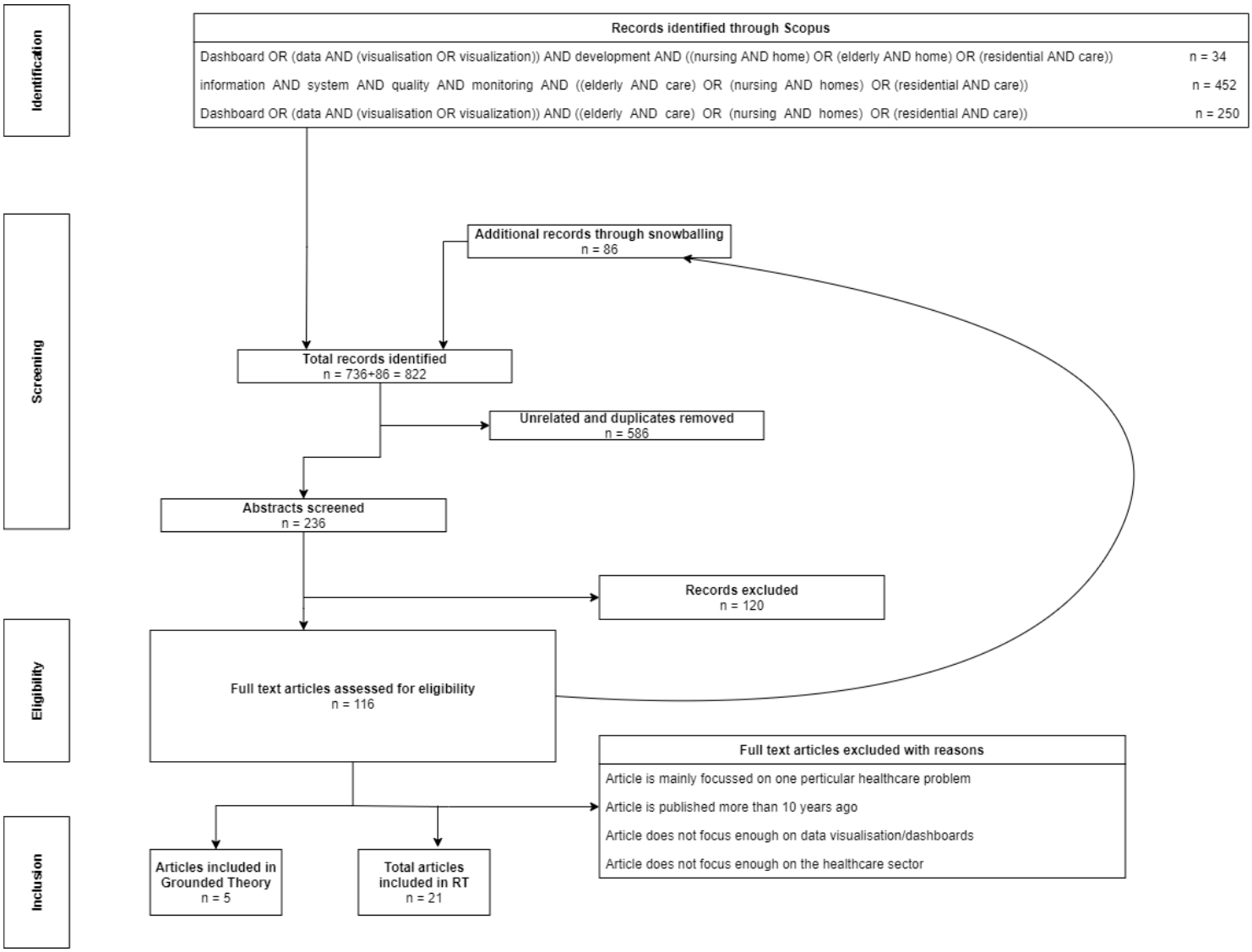

Figure 3: Search Strategy

4 Method

To answer the research questions, a combination of research methods are used. From a methodological perspective, this research project will follow the principles of Design Science Research (DSR). Orlando's dashboard development methodology [1] will be used as a basis for the dashboard development methodology in healthcare organizations. The first research questions and its sub questions will be answered by carefully selecting articles from the literature research and combining them into a dashboard development methodology suitable for heterogeneous stakeholder inside healthcare organizations and in particular nursing homes. For this process, a free interpretation of GT is used. Wolfswinkel et al. mention in their paper about the practical usage of GT the following:

> Obviously here as elsewhere one size does not fit all, and there should be no hesitation whatsoever to deviate from our proposed steps, as long as such variation is well motivated.
>
> – Wolfswinkel et al. 2013

The freely interpreted usage of GT in this research will be further elaborated on in section 4.1. This research aims to develop a strategy for the development of a quality performance dashboard to assist nursing homes making more data driven decision. See Figure 1 for an overview of what the Dashboard Development Methodology in Healthcare (DDMiH) aims to cover and in which fields the research questions fit. This research mainly aims to adapt Orlando T.M. and Sunindyo W.D. dashboard development methodology to a usable dashboard development methodology in the healthcare sector by merging practical experiences derived from the literature and professionals from the healthcare sector and data visualisation experts. The derived experiences of the literature can be found in the appendices. The methodology created with GT, will be referred to as the DDMiH. There are many dashboard development methodologies in the literature that could have been used as a reference, however the existing methodologies do not specify the steps necessary to ensure that the dashboard development methodology is able to accommodate heterogeneous stakeholders, in which each stakeholder has different needs and activities. Orlando's Dashboard Development Methodology (ODDM) has been derived from Eva Hariyanti's [17] which has seven main stages in accordance with the stages of software system development, namely the identification of needs, planning, design prototype, prototype review, implementation, deployment and maintenance.[1] This methodology hereinafter referred to as ODDM is a great method to be used as reference for the DDMiH, which is able to deal with heterogeneous stakeholders in the healthcare sector.

4.1 Grounded Theory usage and deviation motivation

The deviation of this study from the GT as Wolfwinkel et al. explained it, is in the analyzing stage of GT. As mentioned in the search iterations (3.2), there is a gap in the literature which merges dashboard development and nursing homes or even the healthcare sector in general. The literature study found that dashboard development projects are always done in several phases/stages. [18] [6] [1] [17] [19] [14] In a recent study (2017) Orlando T.M. and Sunindyo W.D.[1] adapted Hariyanti's [17] dashboard development methodology to be able deal with heterogeneous stakeholders, as is the case with CareTopics. This methodology however, does not consider the difficulties and opportunities emerging in the healthcare sector. [11] The analyzing stage is more or less replaced by a merging stage, which merges the stages of the dashboard development methodology for heterogeneous stakeholders, with articles that focus specifically on dashboard development experiences in the healthcare sector. An overview of selection reasons for GT can be found in the table below. A striking difference between the selected articles for GT is that dashboard development in the research of Weggelaar et al. [14], seems to start with an inventory of the available data, while in the research of Ghazisaeidi et al. [6], dashboard development seems to start with the selection of KPI's. For the intended merge, it is necessary to have the phases in chronological order. I argue that it is best for dashboard development in healthcare to start with the selection of KPI's. Voluminous amounts of irrelevant data and poor data quality and reliability are of main key factors to utilize dashboards to the maximum extent and to produce reliable results. In order to address issues related to the quality and reliability of data, it is very important to concentrate efforts on improving the data generation processes. Feasibility of selected KPI's is ensured by data availability. So, some new processes may be required to record existing data or generate new data. [6]

Starting with the inventory of the data and therefore rejecting certain KPI's, would undermine these efforts. Weggelaar et al. even mention in their own paper: Respondents state that it is challenging for hospitals to develop and prioritise useful dashboard content due to differing needs for specification. This results in ongoing discussions about the validity and reliability of the data presented on their dashboards. Respondents emphasise that involving healthcare professionals in developing content is important as respondents believe that this will make these stakeholders more likely to endorse and identify with this content.[14]

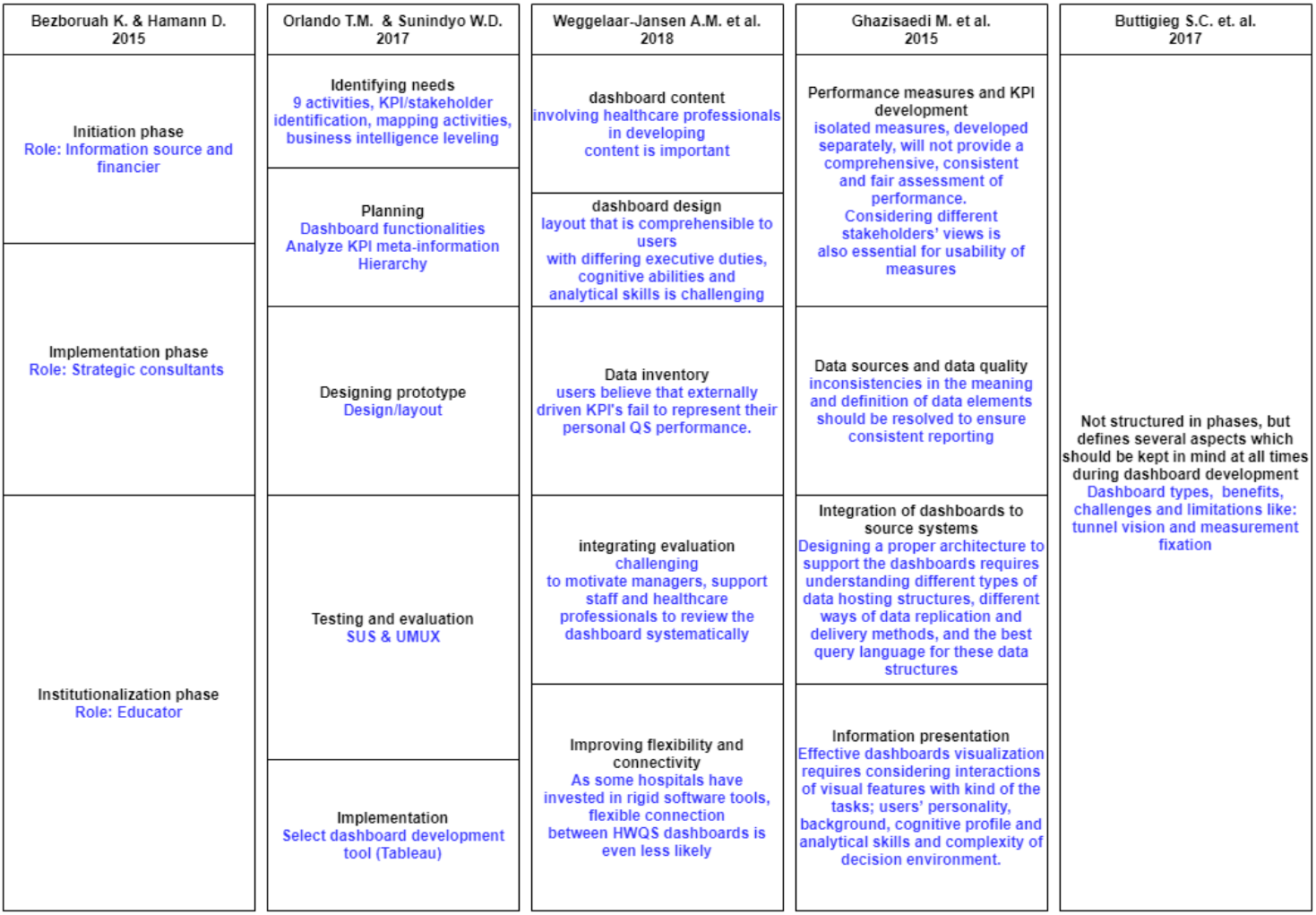

Figure 4: Grounded Theory Dashboard Development phases

Year	Author(s)	Title	Reason(s) for its selection
2015	Bezboruah K. & Hamann D.	A knowledge barrier approach to health IT diffusion in nursing homes: The role of IT vendors	The primary objective of this study was to understand the process of implementation of health IT in nursing homes. During the study, the importance of health IT vendors were underscored by the administrators, employees, and nursing staff. The study found that vendors played multiple roles in the adoption and implementation of health IT. As both Infotopics and Adcase are IT vendors, these findings should be taken into account and applied into the merged strategy.
2015	Ghazisaeidi M. et al.	Development of Performance Dashboards in Healthcare Sector: Key Practical Issues	The aim of this article was to identify key issues that need to be addressed for developing high-quality performance dashboards in the healthcare sector. They found that creating high-quality performance dashboards requires addressing both performance measurement and executive information systems design issues. Covering these two fields, identified key practical issues were categorized to four main domains: KPI development, Data Sources and data generation, integration of dashboards to source systems, and information presentation issues. These issues should be taken into account and applied into the merged strategy.
2017	Buttigieg et al.	Hospital performance dashboards: a literature review	Broad and quite recent literature review of hospital performance dashboards. Despite the fact that this review focuses on performance dashboards in a hospital setting, many of the findings can also be applied in nursing homes.
2017	Orlando T.M. & Sunindyo W.D.	Designing Dashboard Visualization for heterogeneous stakeholders	Hariyanti proposed an information dashboard development methodology for organizational performance monitoring. This research continues on her work to make the methodology able to deal with heterogeneous stakeholders. Good starting point for a dashboard development methodology in the healthcare sector.
2018	Weggelaar-Jansen A.M. et al.	Developing a hospital-wide quality and safety dashboard: a qualitative research study	The literature on dashboards addresses the technical and content aspects of dashboards, but overlooks the organisational development process. This study shows how technical and organisational aspects are relevant in development processes. These aspects can be used in the dashboard development strategy

Table 1: Selection reasons articles used in Grounded Theory

5 Literature research

The literature research did not found any dashboard development methodologies which are specifically intended for use in healthcare settings. The literature research was therefore shifted to combine existing knowledge regarding dashboard development and observations/experiences from other papers regarding the implementation and usage of (quality) performance dashboards in the healthcare sector.

5.1 Dashboard types

- **Strategic dashboards:** Strategic dashboards are used by top management to monitor the execution of strategic objectives and emphasise management, more than monitoring and analysis. Strategic dashboards are usually shared on every level of an organisation to ensure that the strategic goals of the organisation are apparent to everyone. Many performance dashboards are designed to support executive meetings that review strategies and operations.

- **Tactical dashboards:** Tactical dashboards are used by departmental managers, to track processes and emphasise analysis. The analysis application enables users to investigate data across many dimensions to ascertain the cause of a highlighted situation. It also enables users to monitor performance and charts progress against budget and other goals.

- **Operational dashboards:** Operational dashboards enable users, mainly front-line clinical, to monitor the performance of core operational processes in real-time. Monitoring delivers critical information at a glance using relevant and timely data. Within the health care setting, these operational dashboards are known as clinical dashboards as these are used by clinicians. Dashboards provide clinicians with access to relevant and timely information which assist them in their decision-making and thus improve the quality of patient care.

  The different dashboards should not be seen as separate tools. Instead the strategic dashboard should have a cascading effect onto the tactical and operational level in order to attain the alignment towards the organisational goals.

5.2 Orlando's dashboard development stages [1]

As can be seen in Figure 4, dashboard development is done in several stages. ODDM follows the first 5 stages of software system development, namely the identification of needs, planning, design prototype, prototype review and implementation. Deployment and maintenance is out of the scope of ODDM. In section 6 the steps in these stages are explained in more detail and discussed in a healthcare context. Orlando adapted Eva Hariyanti's [17] dashboard development methodology to be suitable for multiple heterogeneous stakeholders [1], which is also the case in the healthcare sector. ODDM will therefore be used as a basis for the development of dashboards in the healthcare sector. Even though ODDM was originally developed for the development of library dashboards, it was the only identified methodology which did not assume a single ideal user.

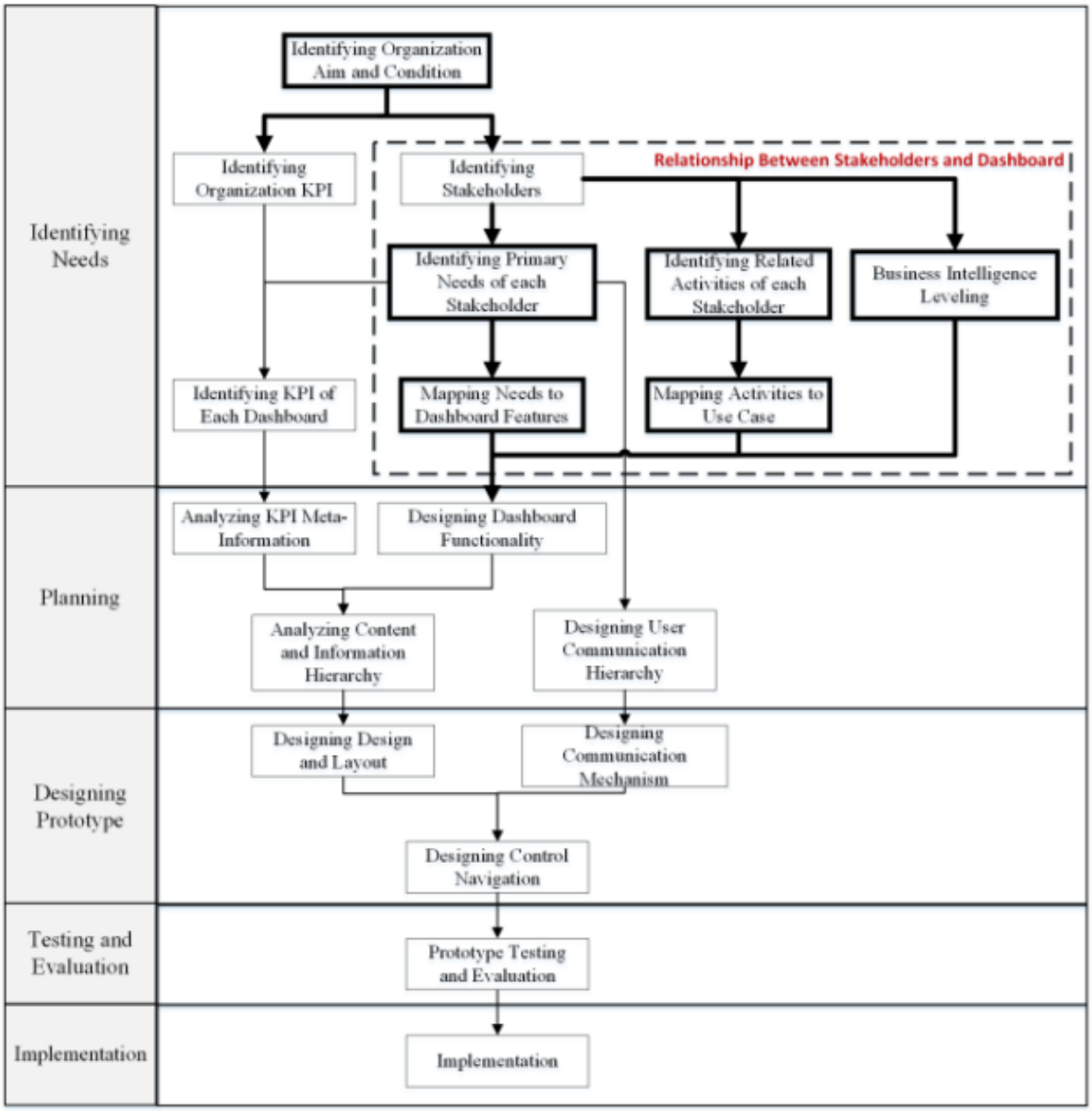

Figure 5: Orlando's Dashboard Development Methodology

5.3 Quality of care & KPI definition

As can be seen in Figure 1, the first iterations of the literature research raised more questions then it answered. This is because the Caretopics project covers several fields which are still in development and researched upon. Quality of care for example, is one of the topics which is important for CareTopics. Without quality of care specifically defined, it is hard to define KPI's for quality of care and thus hard to accomplish a widely accepted quality monitoring system. In other words, it is necessary to define what quality of care actually is, before one can monitor it. This means that the first new research question emerged, namely: Which aspects of healthcare services define if the services are high or low quality? This is a very subjective question, as high or low quality service is very dependant on the experiences and the personalities of the persons judging the service. This problem is known and several countries including the Netherlands are already working on a framework to offer a widely accepted standard regarding healthcare quality. This is important for this research, because the literature regarding dashboard development pointed out that selecting the appropriate KPI's is one of the most important aspects when developing performance measurement systems. [6] Identification of KPI's should be through evidence-based academic literature or consensus of experts to ensure their validity. [6] [14] [1] As this research is not aimed at defining quality of care and efforts to accomplish nationally accepted standards of

quality of care are already set into place [12][13], this research will use those efforts as a base for the definition of quality of care. This means that besides being used, the definition of quality of care will be outside of the scope of this research.

5.4 Dutch Quality Framework Nursing Homes

A widely accepted conception about high-quality, safe and effective services for elderly living in nursing homes is that care should be person-centered, uphold human rights and respect their privacy, dignity and safety. Several countries, including the Netherlands are developing a QFNH, which is conform to this conception. On the 13Th of January 2017 the Dutch government introduced the QFNH. [12] In the first place the QFNH is developed to describe what clients and their loved ones can expect from nursing home care and to assist them in making a well-considered choice for a nursing home organisation. Secondly, the QFNH aims to stimulate healthcare organisations to continuously optimize the quality and support of healthcare services and to reinforce the learning capacity of the healthcare sector. Thirtly, this framework is considered as the basis for external supervision and to purchase and contract healthcare services. The QFNH is developed and agreed upon with a lot of stakeholders from the sector led by V&VN (The Dutch Professional Association of Caregivers and Nurses). These stakeholders include nursing homes, the Dutch National Health Care Institute, health insurers and caregivers.

With the introduction of this QFNH, it is registered in the legal register and made it a mandatory part of the annual report for all nursing homes located in the Netherlands. This register makes publicly available what health care providers, clients and health insurers agreed upon regarding the definition of healthcare quality and forms the basis for supervision and accountability. Since the QFNH is registered, nursing homes are obligated to annually report several predefined quality indicators inside a quality report, which must be publicly published on the Web. This is to promote transparency and to create an incentive to nursing care organisations to put healthcare quality high on their agenda. These quality indicators are not only published in the healthcare organisations' own annual quality report, but are also collected and yearly published online in an Excel file.

The QFNH consist of eight themes, namely:

- Person-centred care and support
- Living and well-being
- Safety
- Learning and improving quality
- Leadership, governance and management
- Staff composition
- Use of resources
- Use of information

Although the QFNH is still in development, every theme of the QFNH has requirements and 'assignment to the sector', in this case nursing homes.

involved parties:

- Actiz
- LOC Zeggenschap in zorg
- Patiëntenfederatie Nederland
- Verenso
- Verpleegkundigen en Verzorgenden Nederland (V&VN)
- Zorginstituut Nederland (ZIN)
- ZorgthuisNL
- Zorgverzekeraars Nederland (ZN)

The QFNH offers instructions and directions for nursing homes to improve the quality of healthcare they provide.
For the themes: 'safety' and 'staff composition' from the QFNH, KPI's are already defined and agreed upon by consensus from experts of the sector and the literature. [12] Unfortunately, the KPI's defined in the QFNH are very much focused at the strategical and tactical management layer of nursing homes. For Adcase, these KPI's require extra attention and some derivatives of those KPI's might need to be created to make them add value for the operational layer of nursing homes. The other themes are work in progress, which means that this research can be done simultaneously with the development of the Dutch QFNH.

5.4.1 Continuing developments Dutch QFNH

For the continuing developments of the QFNH, the Dutch health care institution uses an assessment framework.[20] This framework consists of two sets of criteria which are able to tests new quality standards and measuring instruments. Based on these criteria, the Dutch health care institution assesses whether a quality instrument is a responsible description of high quality care. When quality standards or measuring instruments are considered, their will be evaluated if it is a responsible way of obtaining an indication of the quality of care provided.

5.4.2 QFNH: Safety

Working on quality of care is based on professional standards and guidelines. For safety, this means that care organizations and care providers minimize avoidable damage to clients as much as possible and learn from previous security incidents so they can be prevented in the future. Striving for optimal safety must be a high priority, but must be balanced with other important values in nursing home care. Tensions can arise between personal freedom and well-being on one side, and personal safety and risks on the other. The QFNH has multiple themes which are also divided into themes. The theme 'Safety' is divided into 8 themes, each having its own KPI's. These KPI's will be analyzed to check for which end-users they are most suitable and if they are derivable to be useful for the other end-user types in Caretopics.

5.4.3 QFNH: Staff composition

Without sufficient, authorized and competent staff, high-quality elderly care cannot be provided. The staff composition of a care unit is not static and the need for staff competencies can vary from day to day. Dealing efficiently with the required and available caregivers requires proactively organizing an adequate workforce that includes a sufficient amount of caregivers with the necessary skills and competences. Due to the increase in the level of care, the increasing complexity of care and the decline in the length of stay of clients in nursing homes, tensions have risen between the competence level of care providers and the requirements imposed on them. The literature shows that there a positive relationship exists between the correct level of competence of employees and the quality of the nursing home care. [21] Just like the safety theme, staff composition already has KPI's described. It is useful for Caretopics to analyze the extent to which the KPI's in their current form or a derivative are usable for the different end-user types.

5.5 End user identification and project management properties

All GT examined articles mention the fact that the end users should be identified and involved in whole dashboard development process. Experiences, personality, and cognitive abilities influence end users' approach to performing a task and their understanding of a problem domain. Cognitive-psychology research has shown that such differences can significantly impact a user's dexterity with an interface or data visualisation tool. [15] The type of organization utilizing a dashboard, the type of system user (e.g., direct patient care provider or managerial staff), and the specific purpose for data analysis determine the specific properties of a dashboard. [22]

5.6 The role of IT vendors in IT diffusion in nursing homes

As both Adcase and Infotopics can be seen as IT vendors, their role in the diffusion of health IT should not be neglected in the dashboard development methodology. Vendors are important for breaking down hurdles to adoption and implementation of health IT. [23] Study of the literature regarding dashboard development in healthcare showed that user involvement during all phases of dashboard development is a good idea for several reasons. K. Bezboruah and D. Haman found in their study that the superior strategy would be a strategic partnerships between suppliers and users that involve feedback from end-users of the health IT. [23] Despite the fact that this study was conducted in the USA and healthcare in the USA and the Netherlands is difficult to compare due the the high differences in healthcare systems, the adoption of health IT in nursing homes is still comparable. Bezboruah and D. Haman defined three phases in health IT adaption, namely: The initiation phase, the implementation phase and the institutionalisation phase. Although these phases do not fit directly into the stages of ODDM, the knowledge and experiences from these phases could still be applied overarching the stages of ODDM

5.6.1 Initiation phase

In the initiation phase, K. Bezboruah and D. Haman argue that IT vendors should act as an information source and financier. They elaborated on this fact with an example from one of the researched nursing home:

> In one nursing home, a pharmacy representative brought them information about a new health IT system. The administrator said, "An IT vendor was looking for a guinea pig facility willing to try out their system." Since this nursing facility was dissatisfied with their existing software system, they decided to accept the offer from the new vendor. They sent top-level managers to another state to meet with the developers and other users of the system. They found that it was the most user-friendly system they had encountered, and that by adopting the system, they would be able to provide inputs in the design and customization. The nursing home administrator continued, "the IT vendor would install the software for free in exchange for help with development and serving as a "show" facility. So, it was a very attractive offer. The system was initially set up to do physicians' orders and MARs (Medication Administration Records) and then progressed to assessments, nurses' notes, incident reports and MDS 3.0. (Minimum Data Set)" Start-up fees are prohibitively high for many nursing homes (DesRoches et al. 2008; Cherry et al. 2008; Gin et al. 2011), but this IT vendor eased that burden by installing the hardware at no cost and provided free laptops, with the expectation of recouping the cost from the monthly service charge of around $1000. In exchange, the quality control nurse at the facility provided the vendor with invaluable feedback on the system. Consistent with Attewell (1992), the role of the vendor evolved into one of reducing hurdles to adoption of health IT. The floor staff, though disappointed at not being consulted in the initial planning phase, was satisfied with the new health IT system as well as the training and support provided by the vendor.
>
> –K. Bezboruah and D. J. Haman (2015)

5.6.2 Implementation phase

In the implementation phase, K. Bezboruah and D. J. Haman argue that IT vendors should take the role as strategic consultants. They state that the nursing home industry is very diverse. Some nursing homes are part of big health corporations, others are standalone facilities. Depending on the characteristics of the nursing home, the role of the vendor also changes, which may reflect the diversity in implementation processes and outcomes. Due to the variety of organizational forms in the industry, customization of the software and implementation process are important, and is a key role of the vendors. K. Bezboruah and D. Haman elaborated this with another example from an administrator of one of the researched standalone nursing homes:

> "We are a small facility. We are just by ourselves; we are not part of an organization, most nursing homes are owned by corporations. Well they have that program which supports all their facilities so we had to find someone who would deal only with us because we are a one home corporation, ok? And that's how we determined these people." This facility adopted a software system the vendors tailored to meet the requirements of a small facility. Conversely, the Director of Nursing of a large corporatized nursing facility complained that, "It seems to me like it was written by someone who doesn't know anything about medicine or medical needs as far as our day to day basis. It looks pretty on a technological aspect, you've got these screens with all this information but you're just overloaded with information, it's just too much." The administrators stated that the corporate headquarters funded the health IT system and although the system is supposed to be customized to the facility, it actually is standardized. The users felt that it is overly technical and disconnected from the field of nursing, and not customized to deal with the details and nuances of medical care.
>
> –K. Bezboruah and D. J. Haman (2015)

In all nursing homes, there was an expectation on the part of nursing home administrators and staff that the health IT vendors act as strategic partners during implementation. Administrators relied on health IT vendors to assist making implementation decisions that were in the best interest of the nursing homes, an expectation that was not always met. They refer to a study from Nazare et

al. (2013) which found that technical support, clinical content adequacy and availability, system usefulness and user interface design were among the main factors that have lead to the abandonment of health IT systems in nursing homes. All of these problems could have been reduced had the vendors provided more customization and served as implementation process consultants. [23]

5.6.3 Institutionalisation phase

In the institutionalisation phase, K. Bezboruah and D. J. Haman argue that IT vendors should take the role of an educator. They found that the institution where the IT vendors provided a three week training had a higher satisfaction with the system compared to institutions that relied on a peer-to-peer training dissemination. Peer-to-peer dissemination has several drawbacks. firstly, the employee representative may not fully understand the system, and therefore may not pass on most efficient and effective ways to use the software, resulting in employees not using the software optimally. the employee receiving training may be technologically proficient, but they may not be able to convey complex technologies to others who have little technological background. In nursing homes where training was conducted this way, employees had more difficulty adapting to health IT. Floor staff in some homes complained that training was too brief and inadequate when imparted by vendors, especially for those with little prior computer experience. Consequently, they could not take full advantage of the system. They were forced to learn slowly by practicing on the floor, while simultaneously carrying out their other duties. Floor staff informally sought support and training from their peers. Nursing homes that had minimal training for nursing staff faced the most employee resistance to change. Therefore it is wise as an IT vendor to not only develop and implement dashboards, but also develop training modules to teach end-users how to use those dashboards and show them how the system actually help them in their day to day activities. Administrators of nursing homes can help the IT vendors by scheduling the classes, choose the modules, and recommend extra training to employees with limited IT knowledge.

5.7 Key practical issues of performance dashboards in the healthcare sector - Literature reviews

Ghazisaeidi M. et al. identified several Key practical issues during the development and implementation of high-quality performance dashboards in the Healthcare sector. In their research, they categorized four domains: 'KPI development', 'Data sources and data quality', 'integration of dashboards to source systems' and 'information presentation issues'. This study mainly focused on design phase of performance dashboards and other phases of the dashboards development life cycle were not included in the scope of this study. [6] In each domain, Ghazisaeidi M. et al. identify and describe practical issues that need to be addressed for developing high-quality performance dashboards in complex environment of healthcare sector. An overview of the found key practical issues for each domain is given in Appendix A.

Weggelaar-Jansen A.M. et al. retrospectively studied the challenges faced during the development of hospital wide QS (Quality & Safety) dashboards in Dutch hospitals. They constructed a heuristic model of the development process of these dashboards broken down into five phases, namely: Data inventory, dashboard content, dashboard design, integrating evaluation and improving dashboard flexibility and connectivity.

6 Dashboard Development Methodology in Healthcare (DDMiH)

In this section, the steps of ODDM will be applied and adapted to be suitable for dashboard development inside healthcare settings and in particular nursing homes. Infotopics and Adcase, both commercial companies active in the healthcare sector recognise the problem of increasing workload and at the same time a decreasing workforce in the healthcare sector. They also see the potential value of the huge amount of data generated in this sector, which at this moment is barely being used to extract valuable information and insights. An initiative by Adcase to extract operational healthcare data and generate "action driven" dashboards under the name of "Adcase Insight" already started in 2017. Adcase is a consultancy firm for healthcare organizations establish in 2010 and a business partner of Nedap. They assist healthcare providers with the implementation of ONS® Nedap. ONS® is a collective name for various applications made by Nedap, which assist healthcare organizations with planning, reporting, the creation of healthcare plans for their clients and other tasks such as the administration of provided care. In addition they help healthcare organisations with their accountancy, policies and consult on quality management. Infotopics is a business intelligence company based in Oldenzaal (the Netherlands) established in 2003. Their main focus is to get insights out of data which companies already posses and build dashboards to visualize this data in such a form that appropriate actions can be taken to increase performance and healthcare quality. As mentioned before, the development of quality performance dashboards requires knowledge from multiple fields. 1 Therefore the cooperation between Infotopics and Adcase seems logical, as both companies together in theory posses this knowledge. Additionally, the partnership of Adcase with Nedap is promising when the goal is to attract as many as possible potential customers (nursing homes), because the data has to come from the Electronic Health Record (EHR) and administrative systems of the nursing homes. As can be seen in the picture below, since 2020 Nedap seems to cover most nursing homes in the Netherlands and is still growing at the expense of the competition.

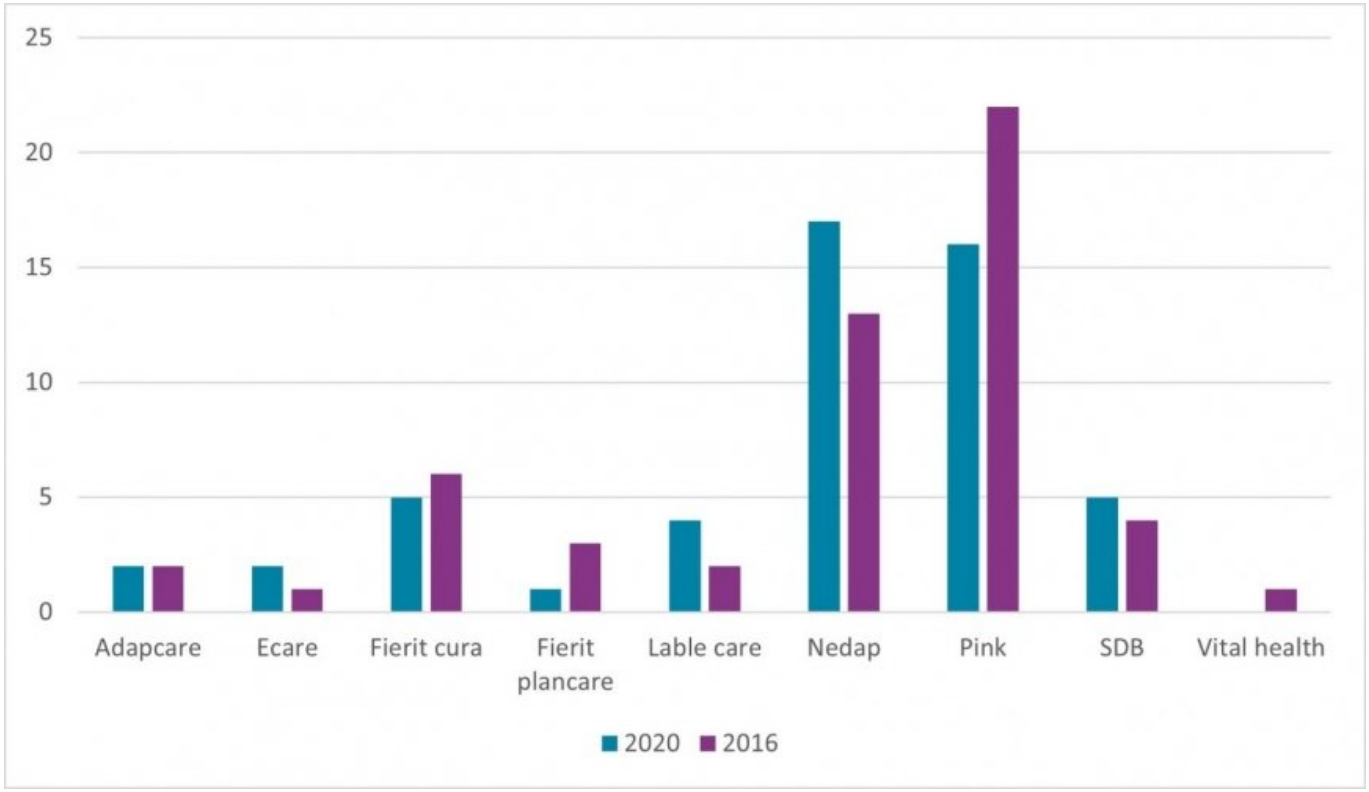

Figure 6: Market share of nursing homes and residential care homes in the Netherlands [24]

Multiple problems and challenges but also benefits and opportunities have been identified in the literature research of this paper regarding dashboard developments in the healthcare sector. An overview can be found in the appendices. Creating an effective dashboard in healthcare settings, ask for a well defined methodology, which is people-oriented and emphatically focuses on the end-users of the dashboards. At the same time, this methodology should also consider other stakeholders involved in healthcare settings, such as governmental inspectorates. Governmental

inspectorates are important to keep in mind during the development of dashboards in healthcare settings. As in many countries, including the Netherlands inspectorates demand annual quality performance data. The extraction of this data currently often requires excessive manual labour, because in many cases this data extraction process is still done by hand using paper archives. In the Netherlands this obligation to deliver annual performance data started in 2016 and the requirements of this data is also growing each year, as these initiatives develop. These themes on which inspectorates require data are also prone to change, as they are part of an ongoing discussion. Previous dashboard development methodologies primarily focus on a single ideal user and only since 2017 multiple stakeholders and end-users are being considered in the dashboard development methodology. [1] In nursing homes and the healthcare sector in general, there are many different end-users and therefore many differences in needs of end-users and thus many different requirements of the dashboards. On top of that, the literature also showed that even if end-users have the same requirements for information, the differences in cognitive ability, personal experiences and characteristic traits can make the same dashboard effective and usable for one user, but ineffective and useless for the other. [4] [22] Ignoring this fact will lead to dissatisfaction and ultimately the abandonment of the dashboard development project altogether. [23] On the other hand, customization of the dashboards for every single user is a time consuming, tedious and thus expensive process. This makes this process commercially unattractive unless these investments can be recouped. Therefore the dashboards development methodology should seek for a balance between standard and customized solutions. Successfully implemented dashboards in healthcare settings have already been proven to be highly beneficial. Important beneficial examples, particularly in healthcare settings are increased communication between different departments, enable informed (data-driven) decision making, reduction of costs and an improvement of patient care. [11] Current methodologies do not accommodate for the different stakeholders and do not emphasize enough on the high variety of needs of the end-users in healthcare settings. This variety in needs do not only occur in the healthcare sector solely, but also in the companies assisting them. This problem already comes up in the very start of the development of this project. Infotopics and Adcase started a cooperation in an attempt to develop a quality monitoring system for the healthcare sector. This system which they named CareTopics, should assist healthcare organisations which use this system in making more data driven decisions to increase the quality of care provided without increasing workload. The so called "low-hanging fruits" with the knowledge both companies already had, was quickly developed and implemented. For Infotopics these low-hanging fruits consist mainly of strategical and tactical typed dashboards, as their experience and product development seems mainly aimed at managers and other administrative employees. Adcase, with the implementation of ONS® Nedap, seems to be more focused on the operational layer of the healthcare sector. Meaning they are focused on helping healthcare employees like nurses, psychologists and occupational therapists. This brings up a concern about the cooperation between Infotopics and Adcase, because they have a discrepancy in their target audience/end-users. [15] Their differences in focus could be seen as a threat for their cooperation or as strength when these differences are well managed and combined to create better dashboards for the healthcare sector. This is why clearly defined roles and responsibilities in the development of dashboards are important.

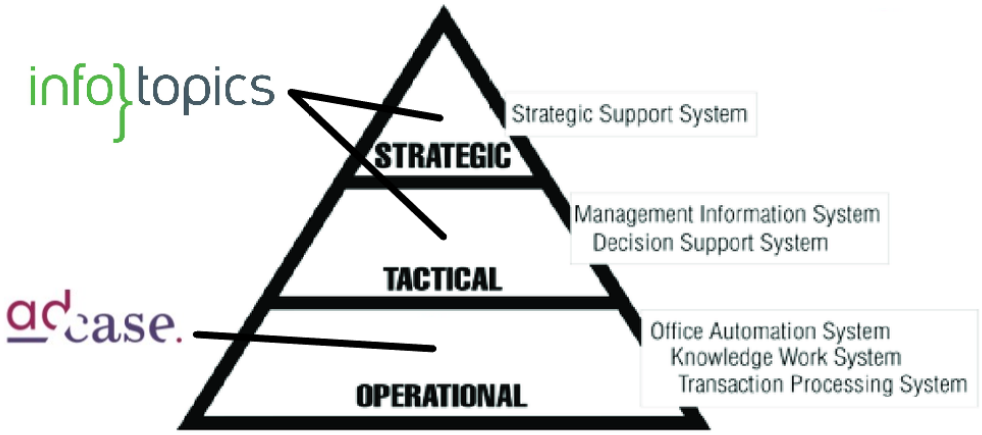

Figure 7: Infotopics and Adcase focus

6.1 Identifying needs

The first stage of DDMiH is the identification of needs. In this stage all the stakeholders and end-users needs are identified and analysed in a logical order consisting of 9 steps.

6.1.1 Identifying Organization aim and conditions

Dashboard development should start with the identification of the organisational aims and conditions. Organizational aim includes the identification of the organization's expected benefits from the dashboard(s), whether the dashboard is built to support operational activities, decision-making, trend prediction, or other goals. In healthcare organizations some additional aims and conditions might occur, as some of those organization have specialized themselves in for example somatic symptom disorder or age-related diseases such as Alzheimer's. In addition, the needs can also be temporary or eventual e.g. the recent program of dignity and pride of Vilans, initiated by the Dutch ministry of Health, Welfare and Sport. [25] Organizational conditions is the identification of the extent to which existing systems in the organization can be utilized in dashboard development or whether the organization already has a clear specification of the dashboard to be built, or the organization has no clear specifications. These aims and conditions are identified by interviews or surveys of stakeholders. In the healthcare sector, the use of surveys is discouraged in the operational layer as it would add extra work for healthcare employees. In the Netherlands, the numerous quality frameworks found on the website of the Dutch healthcare institute, can also be used to stay up to date on the most recent developments regarding healthcare quality standards and focus. As mentioned before, dashboards are originally derived from the business sector. The organisational aims and conditions from organisations of the business sector differs greatly from the aims and conditions which are present in the healthcare sector. Commercial organisations often aim to get and stay profitable or want to reach a specific target audience to sell their product or services to. Publicly funded healthcare organisations do not exist to make a profit. (At least in countries were the healthcare system is publicly funded, such as the Netherlands) This research is not focused on private for profit healthcare organisations, although it might still be useful. In the Netherlands, the government defined in co-operation with the sector in the QFNH what clients and their loved ones can expect from nursing home care and thus what Dutch nursing homes should aim to monitor and improve. This means that the organisational aims and conditions for nursing homes are strongly influenced if not already quite determined by healthcare regulations. Publicly funded nursing homes are constantly trying to ensure the maximum possible individual care and attention, while at the same time trying to manage the high workload with a decreasing workforce. This problem is only getting worse especially during the Corona pandemic, as more healthcare employees have to stay home due to Corona infections. During informal interviews with experts from the field, it was clear that employees working in the healthcare sector are not looking for extra work/administrative tasks, unless it has a clearly noticeable advantage for them. Noticeable advantages are advantages such as a net decrease of administrative tasks or severe quality improvements, like an overall decrease of medical errors or pressure ulcers among clients.

6.1.2 Identifying Organization KPI's

In the case of Caretopics, the identification of organisational KPI's is done using the QFNH. Since the introduction of the QFNH, a few topics regarding healthcare quality inside nursing homes are getting extra high priority. [12] These KPI's from the QFNH are used to identify the KPI's of nursing homes. The first identified KPI are pressure ulcers. Pressure ulcers (also known as pressure sores or bedsores) are injuries to the skin and underlying tissue, primarily caused by prolonged pressure on the skin. This is also the reason why the amount and degree of pressure ulcers are a good indicator for healthcare quality, as most pressure ulcers are avoidable by regularly changing the position of clients. A high presence of clients with pressure ulcers could therefore indicate a low quality of healthcare services, although one should be very careful jumping to that conclusion, as their could be other reasons such as nursing home specialisation that can elucidate a high presence of pressure ulcers. The second KPI this research will focus on is "WZD", which stands for "Wet Zorg en Dwang", meaing law of care and coercion. This law regulates to which extent healthcare can be forced on clients regarding involuntary care and is based on "No coercion unless there are no other options", which normally means if the clients pose a danger for either themselves or others. The less involuntary care is applied in a nursing home, the better the nursing home is able to deal with difficulties without using physical force or other coercion methods. The last KPI is "MIC", which stands for "Melding Incidenten Cliënten" (Report of an incident with a client). MIC is

devided into 3 categories of incidents namely: "Fall incidents", "Medicine incidents" and "Other incidents". The less these incidents occur, the better.

6.1.3 Identifying stakeholders and end-users

In this step, the needs of the stakeholders and end-users are identified In the case of Caretopics, stakeholders include Infotopics, Adcase and nursing homes, but also the Dutch government as they are increasingly demanding more information from nursing homes in the form of quality indicators. [12] The main stakeholders are the end-users (employees in nursing homes), as the dashboards are primarily developed for them. The identification of end-users in nursing homes could be done by interviews or surveys. Important to mention here is the fact that not all end-users are best helped with their own dashboard. Especially in healthcare settings many employees prefer "a good conversation" over numbers, graphs or warnings, which a dashboard system would provide. This is exactly why also the primary needs of each stakeholder needs to be clearly identified and documented in the next step.

6.1.4 Identifying primary needs of each stakeholder

The primary needs of each stakeholder are important to document, as this information clarifies not only if a dashboard would be the best solution, but is also required later on in the dashboard development process if a dashboard was the best solution. The main needs of stakeholders could be the need to do something (execution), perform monitoring (supervision) or make decisions. In addition, the needs can also be temporary or eventual, which is often the case in healthcare settings, due to its highly dynamic nature.

6.1.5 Identifying KPI of each Dashboard

The organizational KPI's which are derived from the QFNH should be mapped to the requirements of the end-user dashboards. Most end-user will not need all the KPI's of the entire organization. The 'less is more' rule applies here, if end-users do not use information displayed, then do not display it.

6.1.6 Business intelligence leveling

Every end-user is a little different because of personal experience, intelligence, character etc. [26] Again it is important to find a balance between customized and standardized solutions, to balance effectiveness and development costs of the dashboards. A successfully applied mitigation to the problem of high development costs due to customization of the dashboards to the end-users, is to shift responsibility of the detailed customization to the administrators or managers of the nursing homes. The administrators of the nursing homes have a much better view of the personalities and capabilities of their employees. Those administrators could then provide feedback to the developing parties, if any changes need to be made. Most nursing home administrators are usually perfectly capable of customizing the dashboards to match the exact needs of their employees, given that the options are available.

6.1.7 Identifying related activities of each stakeholder

The identification of related activities of each stakeholder, is also in healthcare an important step for several reasons. In healthcare organizations multiple differently specialized people are working together often requiring different data in different formats.

6.1.8 Mapping activities to use-cases

When these activities are identified, specific use cases can be defined and mapped to the activities. An example is given in Figure **??** This process is carried out to comprehensively and completely map each stakeholder activities to the appropriate system use case. An obvious example is the government demanding performance data from this system. Many of the nursing homes now have to extract this data manually, often still in paper format which takes quite a lot of their already scarce time, therefore decreasing time that could be spent on actual healthcare activities. A quality performance measurements system would already require this data. This means that this data could be extracted with a single click on a button, which would spare severe amounts of time.

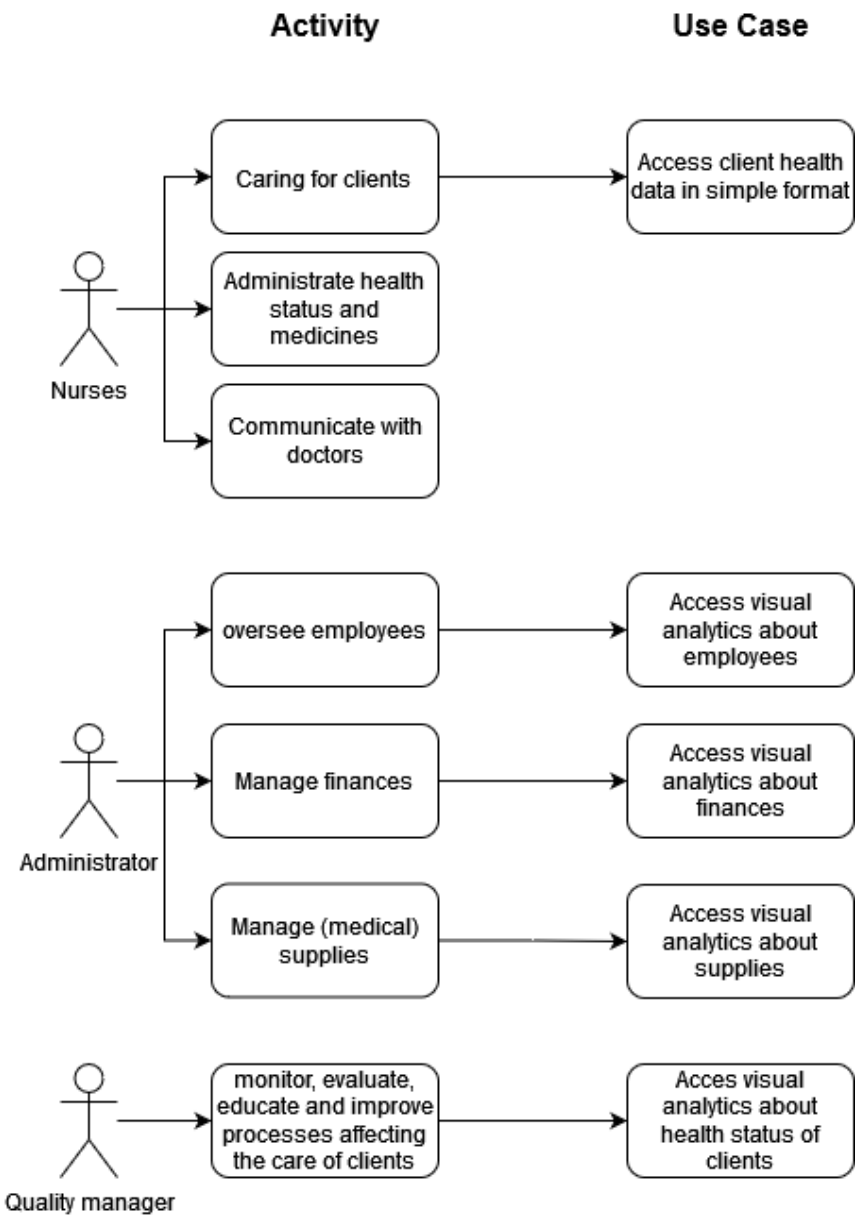

Figure 8: User activities and use case examples

6.1.9 Mapping needs to dashboard features

This step is done to comprehensively and completely map each stakeholder along with its main need to the features on the dashboard. For some of the needs of the identified stakeholders, a dashboard might not be the ideal solution. An obvious example is the need for the annual by the Dutch inspectorate required data. Rather than showing this information in a dashboard, this data could just be exported in a format which the inspectorate accepts. Therefore an export feature should be added to the dashboard of the user which has the responsibility of extracting and delivering this data to the Dutch inspectorate.

6.2 Planning

The planning stage is aimed to analyse the data that is needed to meet the requirements of the identification of needs stage.

6.2.1 Analyzing KPI Meta information

In healthcare organizations, IT is almost exclusively outsourced. For this reason it is important to know which EHR system is used. In dashboard development projects done in healthcare settings, one of the main problems is the extraction of the required data and transforming this into a usable format. Healthcare data is often scattered on multiple databases, which are also used differently across healthcare organizations. This drastically decreases data quality and reliability. Worth mentioning in healthcare settings, is the fact that even when healthcare organizations are using the same software system such as ONS® Nedap, their are still differences in how the system is actually used in practice. This has the result that also the ONS database is used in different ways even though it is the same system. This problem is also visible in the publicly available data, which is published by the Dutch inspectorate. [27] As an example 'food preference' can be taken to make this problem visible. See figure 11. The KPI for the inspectorate is defined as following: "Percentage of clients in the department where food preferences have been discussed and recorded in the care file in the past six months." In practice there are many different ways in how nursing homes take into account the food preferences of their residents. The publicly available data showed that several nursing homes do not register food preferences in the care files of their residents, but rather just ask them in person each evening what they would like to eat. Some nursing homes therefore communicate 0%, as non of the food preferences are recorded in the residents' care files. Other nursing homes communicate a KPI of 100%, because they do take into account the food preferences of their residents, they just do not digitally register those choices. This makes the data invalid for comparison, as nursing homes interpret the actual KPI differently. The data analysis also showed that while the communication of most KPI's is not yet mandatory, they are also often not filled in. See figure 10

6.2.2 Designing dashboard functionality

In this step the actual dashboard functionalities are designed. Dashboard functionalities should be derived from the needs of each end-users, which is defined in the previous steps. Here extra attention should be given to the purpose of the functionality and which end-users is going to use this functionality. If for example a drill-down or filter function is not needed for the particular end-user, do not include the functionality.

6.2.3 Analyzing content and information hierarchy

Content and information hierarchy refers to the strategic arrangement of information visualized on the dashboards. Important information is emphasized more than less important content. There are several ways to emphasize the most important aspects of dashboards, like the placement, font size, spacing, bold, italics, and colour.

6.3 Designing prototype

After the identification and planning stage, a prototype can be made. For the design and development of the dashboards, Tableau will be used. Infotopics has a lot of experience in this field, which means that no problems are expected during this step if the actual requirements and the goals are clearly defined. The design process consist of designing the layout, the communication mechanism and the control navigation. The design and layout refers to determining the number of dashboard screens, the number of frames on each dashboard screen, the composition and sequence of information content, structure and the sequence of information elements in a frame. The communication mechanism can be designed in the form of manually set alerts or messages. Control navigation refers to how the users can navigate between the dashboards and apply filters and drill-down options on the content provided on the dashboards.

6.4 Module testing and evaluation

A dashboard can be regarded as a data driven decision support system, which is able to provide information in a particular format to the decision maker. Hence, dashboards need to be evaluated

according to their design features and by the way users interact with them to make their decisions. [18] Testing and evaluation is important while it validates whether the dashboards are adapted to the needs of the end users. The System Usability Scale (SUS) is a widely accepted way to check for end-user satisfaction, with a score of 68 being average. [28]

6.5 Implementation

During the implementation stage, the appropriate tool has to be selected and used to create the actual dashboard. For this purpose Tableau will be used. Tableau is a data visualization tool, which is also able to connect with various data sources. The Tableau software package comes with understandable directions, examples and visual analysis tools and uses a drag and drop interface which is very intuitive. This makes this software ideal for novices in data mining and visual analysis and makes it possible to design, develop and implement dashboard prototypes in a relative short amount of time.

6.6 Dashboard design validation

The literature research provided multiple validation methods, which could be useful to evaluate and validate Caretopics. Usability evaluation can be executed using the Tasks, Users, Representations and Functions (TURF) method. [29] Under TURF, usability refers to how useful, usable, and satisfying a system is for the intended users to accomplish goals in the work domain by performing certain sequences of tasks. [29] A recent (2019) paper from Dowding et al. [3] describes how they validate the usability of their dashboard to home care nurses. Several methods for validating usefulness, satisfaction and usability are available and should be analyzed to select the most appropriate method to evaluate and validate Caretopics. ODDM uses the SUS and the Usability Metric for User Experience (UMUX) method for evaluation of the dashboards. Using Tableau, the dashboards can be easily published online for the end-user to test. The SUS is already been used quite some time since the development of SUS in 1986 by J. Brooke. [28] and SUS has proven to be a reliable evaluation method for system learnability and usability testing. [3][1]

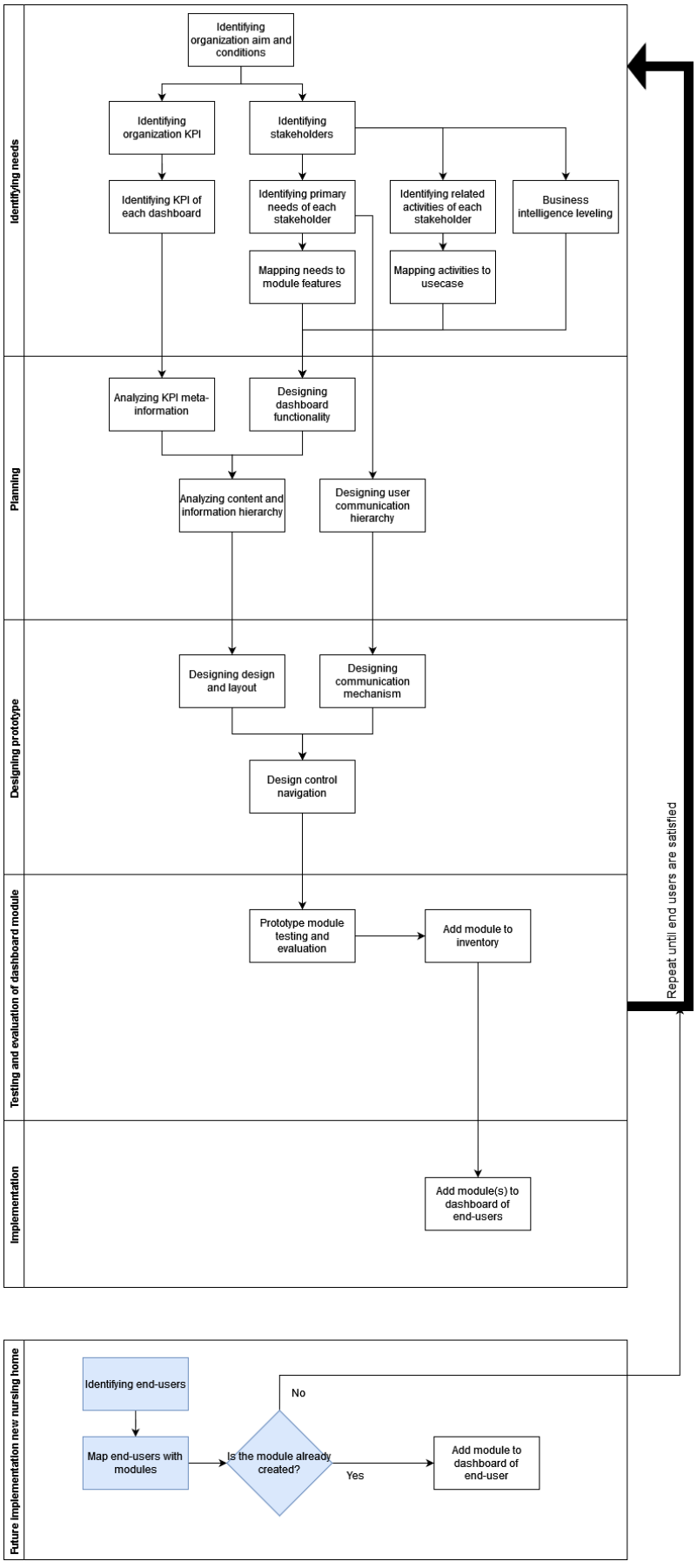

Figure 9: Dashboard Development Methodology in Healthcare

7 Analysis

This section is used to analyse and explain the lessons learned from the case study. The information summarized here, is a result of the literature combined with experience from the case study and interviews with experts from the healthcare sector, Infotopics and Adcase. To get a good idea of how nursing homes work, how IT systems are used in practice and which data is generated, a shift inside a nursing was done.

7.1 Dashboard development methodology

For the development of effective dashboards in healthcare settings, multiple objectives have to be achieved involving many people. This means that besides a well defined methodology which explains the steps needed for effective dashboards in healthcare settings, also a carefully selected project management methodology has to be chosen. This project management methodology has to accommodate frequent communication between the developing parties and end-users. Which specific methodology that should be is out of the scope of this research, but it should be a methodology which has a focus on involving end-users in early stages, such as Agile or Scrum. The DDMiH is very closely related to ODDM, which in his turn was an adaption of existing development methodologies, to accumulate for heterogeneous stakeholders. In the healthcare sector, the development of dashboards is even harder due to the high variety of end-users and thus dashboard requirements. For all these different end-users and requirements, all of the steps of the DDMiH have to be executed, which makes the development expensive in both time and money. Clearly documenting for which end-users and purposes the dashboards are developed, could possibly create an inventory of dashboard modules, which can be reapplied in other nursing homes. These modules should be made for specific end-user use cases as described in the DDMiH.

7.2 End-user involvement

The literature and practical experience make it evident that it is challenging to motivate managers, support staff en healthcare professionals to systematically review the dashboards due to a lack of time caused by the high workload and irregular schedules in the healthcare sector. Failing to involve end-users and healthcare professionals will most likely lead to the abandonment of the dashboards, as users believe that externally driven quality and safety indicators fail to represent their personal quality and safety performance. This end-user distrust together with the many differing needs for specification will lead to endless discussions about the validity and reliability of the data presented in their dashboards.[6] During the whole process of dashboard development in healthcare settings, it should be kept in mind that the end-users are commonly not data analyst. Many of the needs might be better fulfilled without an advanced dashboard, but rather simple alerts, messages or even just a mentioning by the management during monthly staff meetings. The usefulness of alerts was also mentioned during interviews with nurses is nursing homes. As a concrete example, a nurse mentioned that she did not know if one of her clients had showed any bowel movements in the past days, as not all of here colleagues report this in the system. The ability for her to set an alert to report this daily, would be a function of great value.

7.3 Data sources, data quality and language unity

The identification of the source of data for each KPI is one of the most important aspects of dashboards development, as this data can be stored in various inconsistent data sources. In the Netherlands this is unfortunately the case. Healthcare data at this moment is often incomplete, incorrect or outdated. In example, findings from a doctor are often not found in the places of the care files of the patients where you would expect to find them, which impedes data extraction. [30] The same phenomenon can be seen in the current version of Caretopics. Quite a lot of the dashboards remain empty, due the absence of the required data in these healthcare organisations. This greatly reduces the value of the dashboards, as they no longer display (valid) information. The introduction of the QFNH is a great step towards a standard definition of quality inside nursing homes, but also asks for special attention and a lot of extra work collecting and reporting this information. This QFNH can provide directions of which KPI's are a valuable and quantifiable measure of quality performance inside nursing homes, however they are still part of an ongoing discussion. In practice could only be concluded, that the data generated in nursing homes is currently not usable to derive valid information which could be shown in the dashboards. Many nursing homes report daily activities in plain text reports, which makes data extraction very challenging and prone to

misinterpretation. These daily activities were in practice reported according to "SOAP", which stands for: "Subjective, Objective, Analyse and Plan". The idea behind this reporting method is to generate consistency along observations of the nurses. Unfortunately analysis of these reports still show many differences between observations as they are still very sensitive to interpretation of the nurses on duty. Many sensitive observations and incidents are not reported in the system, due to the reason that family and relatives are also able to see them trough "Caren zorgt" (an addition to ONS® Nedap). Practical experiences showed that family and relatives could react quite insulted and sometimes even aggressive to harsh truth, which made nurses reluctant at reporting those incidents in the system. They rather choose for a more internal communication in the form of verbal communication during the transfer of shifts. One of the quality managers also mentioned that when "MIC meldingen" (incident reports) were analysed, there could be noticed that there were significantly less reports during summer periods. Pure data analysis would therefore conclude a lower error rate in summer, however this drop in reports was not due to actually less errors. During summer periods, there are more temporary nurses active, because of holidays of the regular nurses. According to the manager these temporary nurses often make more mistakes, but are not familiar with the system. This results in the fact that these incidents are not reported, which explains the summertime drop of incidents.

7.4 Cultural change, standardization and law

Cultural change in the healthcare sector towards a more data driven culture is going on, however the sector is far behind compared to the business sector. The problem of administrative task taking huge amounts of time is far worse and the primary reason for low healthcare quality. The transfer of patients from a hospital to a nursing home or vice-versa can easily take over 4 hours per client. Nurses have to copy, paste and retype information between several systems multiple times, with a chance of making mistakes every time they do. This time spend on administrative task and correcting mistakes cannot be spend on providing direct healthcare services. Some information exchanges are already in place due to efforts of the healthcare sector. General practitioners and pharmacists are already able to electronically exchange medical information, but hospitals and nursing homes often lack this ability. Several initiatives and a new law for information exchange are currently being worked upon, which would make (reliable) data analysis possible. This law called "Wegiz" (Wet Elektronische Gegevensuitwisseling In de Zorg) is expected to be implemented in 2023. [31] This law, in combination with quality frameworks will set standards on data format and how to exchange this data. This law will obligate all healthcare organizations to work with this standard, with the main goal of making healthcare systems inter-operable, a decrease in administrative tasks and less errors. IT vendors of health IT systems will be obligated to certify their systems according to the new standards, set by the NEN, which is the Dutch normalization institute. This means that in the near future, all health IT vendors in the Netherlands will need to invest extra, to be compliant to these norms. Otherwise, the use of healthcare data will no longer be allowed. [31] The first set of standards is called: "Basisgegevensset Zorg" (Basic dataset healthcare), which defines a standard for healthcare data which is considered the absolute minimum required data to guarantee the continuity of healthcare. [32] The contents of this basic dataset can be found here.

7.5 Data visualization

Data visualization generally relates to to dashboard design features. In dashboard design, visual and functional features should be distinguished. Visual features are concerned with how efficiently and effectively information is presented to the user. If the information showed on the dashboards is too advanced or too much, there is a high change of information overload, which makes a dashboard ineffective. This problem is further exacerbated when dashboards are poorly designed with respect to how information is presented, which often more distract than guide decision makers' attention. [18] Functional features describe what dashboards can do, such as drill-down capabilities, real-time notifications, interactive sorting or expanding and collapsing groups. These functional features should fit with its intended purpose, as it otherwise may lead to incorrect decision making. [6] Infotopics has a great amount of experience in the field of visualizing data in the form of dashboards, while Adcase has the knowledge and experience to select the information which would have the highest impact on quality improvements. Existing research on the use of clinical dashboards in healthcare settings, has identified considerable variability in their impact on outcomes.[33] There are several reasons for this variability, such as differences in the use of graphical displays (e.g., bar graphs or line graphs) or it could be due to variations in the levels of experience and expertise

among clinicians. [26] This is exactly why the end-users should be well defined in the case of Caretopics, as cognitive factors such as spatial ability affect how individuals perceive and use data presented in visualizations. [15]

7.6 Dashboard benefits

Quality performance dashboards could help organizations to evaluate their performance and translate them into data-driven actions to increase the quality of their services. The effect of certain intervention on their provided services can be more accurately monitored. Abnormally high error rates or incidents could effectively be noticed and suitable action could therefore be taken. Dashboards give users immediate access to data, allowing them to take action immediately. Managers do not need to ask someone to write a report about a problem or to wait for the monthly report, greatly decreasing their response time on a deviation from the norm. The ease of access which dashboard provide, make the data readily available in a timely fashion. One of the functions of performance dashboards is to report trends, and hence any exceptions to trends will raise awareness about a problem. [11] Further analysis could help managers identify the root of the circumstances and take appropriate actions before it causes a problem. Downding et al. [34] concluded that implementing clinical dashboards, which provide readily available access to information, can improve adherence to quality guidelines and hence improve patient outcomes and the quality of care.

7.7 Dashboard limitations

Dashboard limitations can be divided into technical and sociocultural factors. The primary technical limitation mentioned in the literature that limits the usefulness of dashboards, is the lack of standardized terminology used in administrative systems and electronic health records in nursing homes. and the lack of standardized definitions for key performance indicators. [22] This was consistent with experiences mentioned by experts and was also identified in the publicly available data. (6.2.1) Data management processes like entry, storage and data retrieval currently used in clinical settings do not always support dashboard utilization because data is not always aggregated in a meaningful format or are distributed over multiple systems that do not communicate with another. Small organizations will not benefit as much from dashboards as larger organizations will. Dashboards are less efficacious for small data sets or measuring rare events because the increased variability in the key performance indicators makes them unreliable for trending purposes. [22]

It was evident from the literature that any setting requires significant effort, especially to ensure the quality of data being collected and the end-users being involved in the development process. In fact, significant investments, both in terms of financial and human resources, are required to achieve an effective dashboard. This is even more the case in healthcare settings, as there are often many differing needs for specification, which can only be met by involving end-users and healthcare professionals into the dashboard development process. This means that the dashboards and the visualized data need to be evaluated continuously. Standardized effective dashboards, which are applicable or easily adaptable to almost every nursing home is impossible to accomplish without significant effort and serious financial investments from multiple parties. Fortunately, these efforts and investments are already set into place and a new law resulting from these efforts is expected to take effect in 2023 or early 2024. [35] The literature mentions multiple times that in the healthcare sector "standardized" and "effective" do not go well together. [23][22][18] For effective dashboards in the healthcare sector, the dashboards need to be adapted to the actual end-users which directly contradict with the idea of standardized dashboards. The literature even advised nursing home administrators to choose a health IT vendor which customizes the dashboards to their needs, instead of a standard solution. [23] As of now 60 other companies are already active in this market, meaning there is severe competition. [36] Effective dashboards for nursing homes can now only be realised with significant customization efforts, to make them fit with the intended end-users and his or her activities. Unfortunately, this would probably make it commercially unattractive. When quality standards are achieved in both "language" and technology, it gets worth it to do the dashboard development cycle. Important costs saving aspect, would be that the first stage of identifying needs, which is also the most time consuming stage (and thus most expensive), would go much faster, as the quality improvement goals will be largely predefined by governmental standards.

8 Conclusion

This research pointed out that despite the numerous advantages of performance dashboards, several papers and experts have mentioned a number of challenges while adopting, implementing and maintaining these quality performance management tools in the healthcare sector. These challenges also showed during practical experiences while doing a shift in a nursing home myself. This research also proposed the addition of dashboard modules, which could make it easier to implement dashboards in the future, if matching end-users and their use cases are identified. This research also concluded that unfortunately many nursing homes currently do not posses the required data quality and reliability to execute reliable quality performance measurements and monitoring. On the bright side, there are multiple initiatives and programs already in place, which are focused on tackling this problem and enforce a more data driven culture in the healthcare sector. When unity of language and data is reached, helpful quality data analysis can be done and visualized in dashboards.

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A Key practical issues of performance dashboards in the healthcare sector

- KPI Development:
  - Well-defined KPI's exactly indicate where corrective actions should be adopted.
  - Focussing on few measures can potentially lead to ignore other important performance areas or functional and environmental features.
  - Isolated measures, developed seperately, will not provide a comprehensive, consistent and fair assesment of performance.
  - Identification of KPI's should be through evidence-based academic literature or consensus of experts to ensure their validity.
  - Considering different stakeholders' views is essential for usability of measures.
  - KPI's should be aligned with organizations goals and mapped to specific strategic objectives to provide dashboards ability to measure, monitor and analyze their attainment.
  - Development of metrics dictionary is also suggested to get detailed understanding of the individual metrics including their name, purpose, equation, target, thresholds, units of measure, frequency of recording and reporting, and data source(s)
  - To ensure management commitment to KPIs, the owner(s) of each KPI should be assigned
  - Interconnectivity between selected measures is an important concern in dashboard development, establishing hierarchical structure of measures or identifying lead and lag measures (i.e. manageable against result measures) is necessary for investigating their mutual impacts and providing drill down capability of each KPI.
  - The number of KPIs should be limited, KPI's should be concerned to high priority areas
- Data sources and data quality:
  - Identifying the source of data for each KPI is one of the most essential aspects to develop dashboards, as data may be stored in several inconsistent source systems such as organization information system, accounting system, human resource systems, etc,.
  - Inconsistencies in the meaning and definition of data elements should be resolved to ensure consistent reporting.
  - Feasibility of selected KPI's is ensured by data availability. Some new processes may be required to record existing data or generate new data.
  - Voluminous amounts of irrelevant data and poor data quality and reliability are of main key practical issues, to utilize dashboards to the maximum extent and to produce reliable results.
  - In order to address issues related to the quality and reliability of data, it is very important to concentrate efforts on improving data generation processes
- Integration of dashboards to source systems:
  - Designing a proper architecture to support the dashboards requires understanding different types of data hosting structures, different ways of data replication and delivery methods, and the best query language for these data structures.
  - Integration of different data sources, creating flexible reports and multidimensional analysis require BI-based back-end infrastructure including data warehousing and online analytical processing.
  - Updating dashboards requires complete data processing procedure. So, the speed of this process determines dashboards data refresh rates and updating intervals.
- Data Presentation:
  - Visual and functional features should be distinguished.
  - A good balance between visual complexity and information utility is necessary.

- Effective dashboards visualization requires considering interactions of visual features with the nature of the tasks, users' personality background, cognitive profile, analytical skills and complexity of decision environment.
- Decision makers with a low level of analytical skills make better decisions when they use a graphical format compared to a tabular format.
- When the complexity of the decision environment increases, tabular formats are generally preferred to graphical formats.
- Considering the option to change display format (i.e. to tabular format or graphs) based on user needs is essential for dashboard visual flexibility.
- Functional features of the dashboard should fit with its purpose(s), otherwise, it may result in incorrect decisions.
- Exact distinction among these purposes is a major determinant of dashboards functional features.

B Challenges during the development of a hospital-wide quality and safety dashboard

- Data inventory:
  - Users believe that externally driven Quality Safety (QS) indicators fail to represent their personal QS performance.
  - In this first phase the challenges are to balance the needs of external and internal stakeholders and to combine qualitative and quantitative QS data, without increasing the administrative burden.
- Dashboard content:
  - It is challenging for hospitals to develop and prioritise useful dashboard content due to differing needs for specification. This results in ongoing discussions about the validity and reliability of the data presented on their dashboards.
  - Involving healthcare professionals in developing content is important as respondents believe that this will make these stakeholders more likely to endorse and identify with this content.
  - Validated, reliable measurement of dashboard content is further complicated by storing QS data in fragmented and incompatible source systems (eg, patient health record systems, human resource systems, accounting systems) making it difficult to extract the dashboard content.
  - The main challenges in this phase are to overcome the discussion about the validity and the reliability of the indicators and to extract relevant content from existing IT-systems.
- Dashboard design:
  - It is challenging for hospitals to design an inclusive layout that is comprehensible to users with differing executive duties, cognitive abilities and analytical skills.
  - To achieve congruence, hospitals often rely on the following graphics: bar and column charts to display comparisons; scatter and bubble charts to demonstrate relationships; line and column histograms to present distribution; donut, pie and waterfall charts to show composition and run and area charts to depict progress. Respondents add that these charts are only effective if they are continuously updated and show real-time QS data, which increases the likelihood of users identifying with and acting on this QS data.
  - To be broadly comprehensible, HWQS dashboards should also use colour to clarify content.
  - Users do not always respond well to traffic light coding, as they often feel ashamed if their performance lingers in red too long and this discourages users from acting on the dashboard. Respondents recommend using neutral colour coding.
  - Clarifying text contributes to comprehensibility.
  - HWQS dashboard should be equipped with several functionalities that enable users to tailor the content to their specific needs.

  - Respondents often state that they would like to be able to save their personal settings for dashboard content.
  - The challenge is to find a layout that suits the needs of different users and provide understandable charts (in the right form and colours), clarifying text and sorting functions.

- Integrating evaluation:
  - Hospitals find it challenging to motivate managers, support staff and healthcare professionals to review the dashboard systematically due to lack of time, high workload and irregular schedules.
  - The main challenge of this fourth phase is to embed collective discussion of the content of HWQS dashboards in quality deficiency prevention (quality assurance) and continuous quality improvement processes.

- Improving dashboard flexibility and connectivity:
  - Hospitals are subject to continuously changing national QS regulations, legislation and policies, respondents argue that HWQS dashboards should be flexible enough to adjust to the requirements and priorities of external stakeholders. This can be done by connecting their dashboards to the data systems or dashboards operated by external stakeholders (eg, healthcare inspectorate, patient associations, external registries).
  - HWQS dashboards should be flexible enough to depict content from other internal dashboards. That would permit contextual analysis and multidisciplinary decision-making.
  - mutually intertwined dashboards become crowded with a variety of indicators so that they lack visual simplicity. Therefore, most dashboards have flexible content, consisting of partly exchangeable QS indicators, which can be added or removed if relevant to (departmental) context.

- Discussion:
  - Hospitals consider data availability a priority as they make data inventories beforehand to determine the available QS data. However, this presents hospitals with a challenge as available QS data are often quantitative and summative in nature (used for external accountability), while users also desire qualitative and formative QS data. (used for internal quality improvement)
  - Actual dashboard development often starts with the translation of available QS data into useful dashboard content. Accordingly, this study shows that hospitals proceed by developing useful dashboard content, which is challenging as users have different needs.
  - Hospitals continue the development process by designing broadly comprehensible dashboards. This is challenging due to the varying tasks, skills and abilities of users. To achieve a broadly comprehensible layout, hospitals should ensure that real-time graphic/visual presentation of content fits the purpose of the dashboard.
  - Dashboards become more effective when their content is frequently reviewed.
  - HWQS dashboards can improve QS performance only when they are technically adequate and embedded in the organisation.

C Hospital performance dashboards: a literature review

- **Performance dashboard types:**
  - **Strategic dashboards:** Strategic dashboards are used by top management to monitor the execution of strategic objectives and emphasise management, more than monitoring and analysis. Strategic dashboards are usually shared on every level of an organisation to ensure that the strategic goals of the organisation are apparent to everyone. Many performance dashboards are designed to support executive meetings that review strategies and operations.

  - **Tactical dashboards:** Tactical dashboards are used by departmental managers, to track processes and emphasise analysis. The analysis application enables users to investigate data across many dimensions to ascertain the cause of a highlighted situation. It also enables users to monitor performance and charts progress against budget and other goals.
  - **Operational dashboards:** Operational dashboards enable users, mainly front-line clinical, to monitor the performance of core operational processes in real-time. Monitoring delivers critical information at a glance using relevant and timely data. Within the health care setting, these operational dashboards are known as clinical dashboards as these are used by clinicians. Dashboards provide clinicians with access to relevant and timely information which assist them in their decision-making and thus improve the quality of patient care.

    The different dashboards should not be seen as separate tools. Instead the strategic dashboard should have a cascading effect onto the tactical and operational level in order to attain the alignment towards the organisational goals.

- **Benefits performance dashboards:**
  - Improved performance
  - Enhanced visibility and integration of information
  - Increase communication between different departments
  - Raise awareness of a problem
  - Delivery of actionable information
  - Enables informed decision making
  - Accelerate organisational change
  - Reduction of costs
  - Improve patient care
- **Challenges to implementation of performance dashboards:**
  - Resistance to change
  - High financial and human resources required
  - Data collection
  - Real-time versus latent information
  - Setting standards
- Despite the numerous advantages of performance dashboards, several authors have mentioned a number of challenges while adopting, implementing and maintaining these performance management tools. It was evident from the literature that any setting requires significant effort, especially to ensure the quality of data being collected. In fact, significant investment, both in terms of financial and human resources, is required to achieve an effective dashboard.

D SUS - questionaire (Dutch)

1. Ik denk dat ik dit product frequent zou willen gebruiken.
2. Ik vond het dashboard onnodig ingewikkeld.
3. Ik vond het product makkelijk te gebruiken.
4. Ik denk dat ik technische support nodig heb om het product te gebruiken.
5. Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.
6. Ik vond dat er te veel tegenstrijdigheden in het product zaten.
7. Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.
8. Ik vond het product omslachtig in gebruik.
9. Ik voelde me zelfverzekerd tijdens het gebruik van het product.
10. Ik moest veel over het product leren voordat ik het goed kon gebruiken.

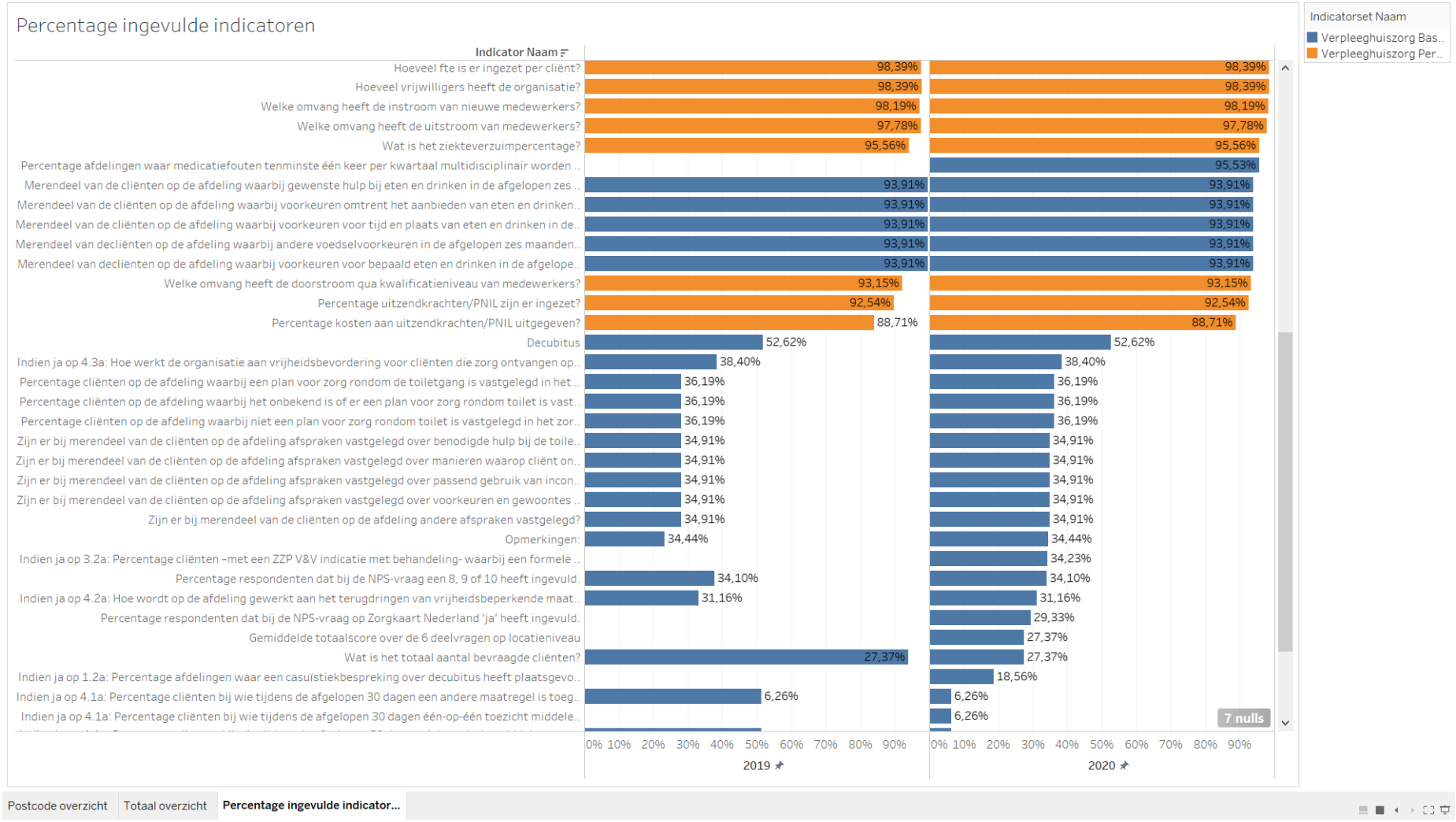

Figure 10: Public nursing home data in Tableau - % filled in indicators

Figure 11: Score comparison on 3 indicators in Tableau