Deliverable 5.1

T0 base line measurement of the KPIs

Big Data for Medical Analytics

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Management Summary

This document describes the T0 baseline measurement of the KPIs identified in the preceding deliverables 2.1; 3.1 and 4.1. The KPIs will be used to evaluate performance developments over time per pilot.

Evaluating performance in health care organizations has to take into account that organizations pursue multiple financial and non-financial objectives. Performance development will therefore be monitored from a healthcare delivery perspective in four dimensions: patient satisfaction, process outcomes, patient outcomes, and financial outcomes. Collecting KPIs in these four dimensions allows us to assess perceptions and experience of patients with health care delivery and the results thereof (patient satisfaction), to evaluate activities performed for care delivery (process outcomes), to monitor effects of care on patients' health status (patient outcomes), and to examine monetary implications (financial outcomes).

The selection of KPIs within these dimensions is pilot-specific and tailored to the pilot's patient cohort, intervention and aim. For each pilot, baseline measurements have been identified and will be described subsequently.

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1. Introduction and overview

1.1. Purpose of the document

In the BigMedilytics project we aim to show how the use of big data technologies can lead to an increase of productivity[1]. There are three main reasons for an immediate innovation action to apply big data technologies in Healthcare. Firstly, a healthy nation is a wealthy nation. An improvement in health leads to economic growth through long-term gains in human and physical capital, which ultimately raises productivity and per capita GDP. Secondly, the healthcare sector is one of the most expensive sectors, which accounts for 10% of the EU's GDP and is continuously becoming more expensive. Thirdly, healthcare is traditionally very conservative with adopting ICT. Since the introduction of especially electronic patient records, big healthcare data is becoming available. The expected impact of applying big data technologies in healthcare is enormous. The BigMedilytics project aims to support the transformation of Europe's Healthcare sector by using state-of-the-art big data technologies. Serving as best practice experiments we can serve as a 'lighthouse' showing how to achieve breakthrough productivity in the sector, covering the entire healthcare continuum – from prevention to diagnosis, treatment and home care throughout Europe. Productivity can be increased by reducing cost, improving patient outcomes and delivering better access to healthcare facilities simultaneously. To show this increase of productivity we need to measure this over the duration of the project. Therefore, we defined per pilot KPI's (see deliverable 2.1; 3.1; 4.1). This document describes the T0 baseline measurement of the KPIs identified in the preceding deliverables 2.1; 3.1 and 4.1. The KPIs will be used to evaluate performance developments over time per pilot.

In organizations in general, evaluating performance has to take into account that organizations pursue multiple objectives. These objectives can be interrelated and focusing only on one objective might neglect important information and can dilute any impact assessment. Therefore, any analysis of performance and/or productivity requires a holistic approach capturing multiple dimensions. For a widely accepted application of this in generic businesses, we refer to the Balanced ScoreCard (Kaplan & Norton, 1992).

Also in healthcare and healthcare management, this notion of multi-dimensionality of performance is important, and well established in academic literature (e.g.: Bos et al, 2017). Although literature makes various distinctions between these multiple dimensions, a central tenet is the distinction between financial and non-financial performance, as well as the distinction between processes and output/outcomes. This is also a cornerstone in the design of the Balanced ScoreCard.

Following this design, we monitor productivity developments in the following four dimensions: patient satisfaction, process outcomes, patient outcomes, and financial outcomes. Collecting KPIs in these four dimensions allows us to assess perceptions and experience of patients with health care delivery and the results thereof (patient satisfaction), to evaluate activities performed for care delivery (process outcomes), to monitor effects of care on patients' health status (patient outcomes), and to examine monetary implications (financial outcomes).

The selection of KPIs within these dimensions is pilot-specific and tailored to the pilot's patient cohort, intervention and aim. The novel character of the big data approaches in the pilots requires that the set of KPIs is not considered statically and can even alter depending on the availability of new data. In deciding on the pilot's baseline period, two aspects were guiding: First, the time period should be a representative extract of the pilot's pre-intervention situation (representativeness constraint), and second, data has to be accessible at the point of writing this report (feasibility

[1] It is important to note that we use both the terms 'productivity' and 'performance', following Djellal and Gallouj, (2013). Djellal and Gallouj (2013) argue that 'performance' presents a more pluralistic approach that fits with the multidimensional nature of public sector organizations. Productivity has a rather 'absolute' connotation, related to economics and the concept of growth, which is particularly unsatisfactory especially in public services and more generally in non-market services).

constraint). Obviously, these constraints required a trade-off, in particular for time-lagged data. Therefore, baseline measurements can be retrospectively expanded if additional data becomes available in which case the set of KPIs will be updated.

For each pilot, baseline measurements have been identified and described subsequently.

1.2. Related documents

- Deliverable 2.1
- Deliverable 3.1
- Deliverable 4.1

2. Section

2.1. Baseline measurement for WP 2 Chronic Disease Management

This work package consists of five pilots, which target the major groups of chronic diseases in Europe. The generic aim of the pilots is to ensure that costly secondary care is only provided to high-risk patients and that measures are taken to prevent exacerbations and complications of existing conditions.

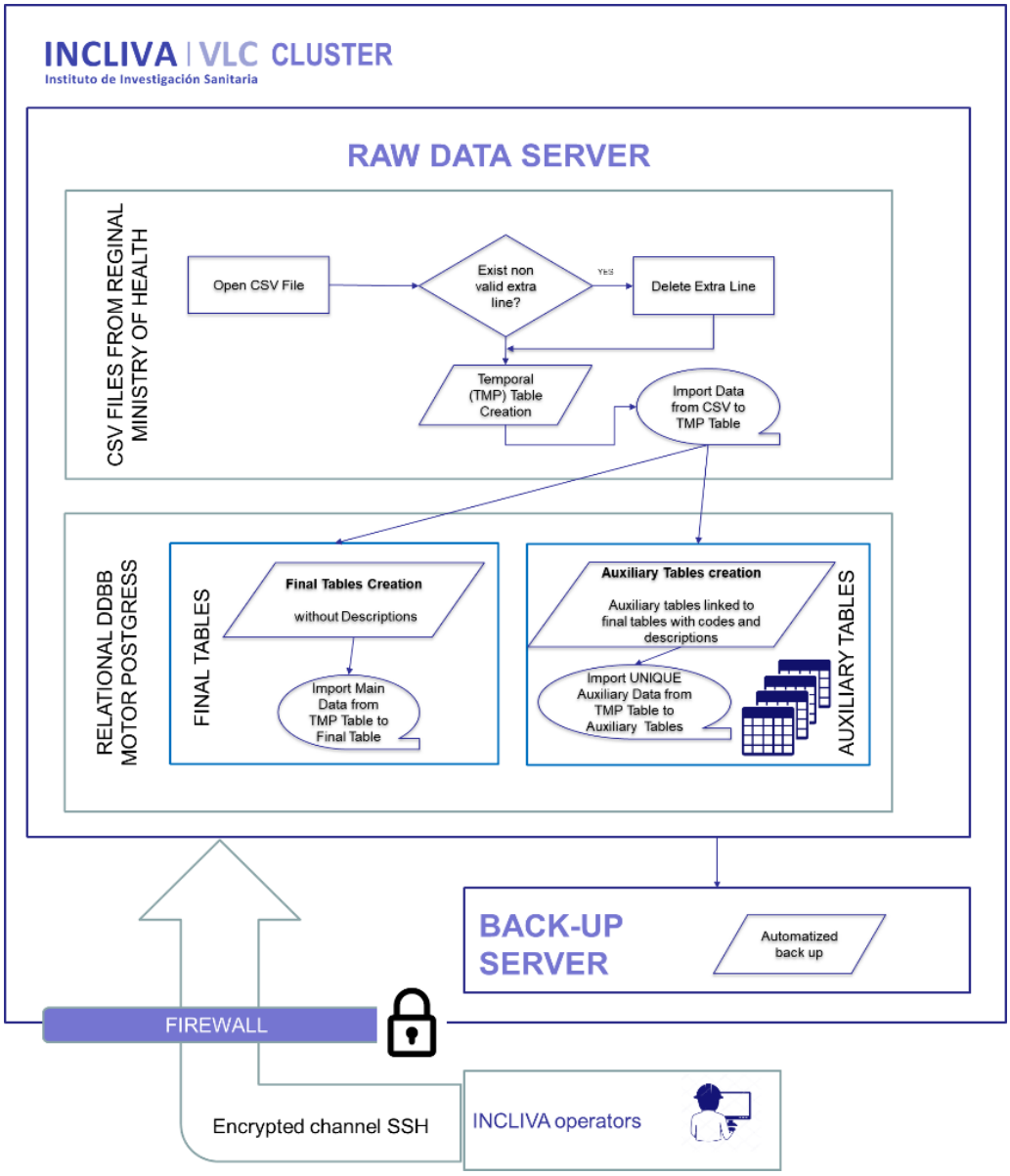
2.1.1. Pilot 1: Comorbidities

The objective of this pilot is to reduce admissions to secondary care by directing low risk patients to primary care and high risk patients to secondary care, thus reducing highly expensive emergency care and hospitalizations. In the retrospective part of the pilot, clustering/stratification and risk prediction algorithms will be used to analyse the primary and secondary care health records of 4 million patients. In the prospective phase, the models built in the retrospective phase will be used to inform healthcare providers of the predicted risk level of a single patient. Since the risk-prediction models are currently under development, clusters with similar risks have not yet been defined. KPIs will therefore be reported for the most common comorbidities diabetes, hypertension, depression, arthritis/arthritis, atrial fibrillation, chronic kidney disease, COPD, heart failure, stroke, coronary heart disease and peripheral vascular disease.

The baseline measurement is extracted from a series of registries provided by the Regional Health Ministry of Spain:

- Therapeutic groups level 3: 170 registers
- Therapeutic groups level 5: 753 registers
- Diagnostics CIE9: 16,559 registers
- Procedures CIE9: 1,328 registers
- Clinical Risk Groups: 10 registers
- Health status: 1,074 registers
- Causes of remove: 8 registers
- Emergency room attendance: 9 registers
- Pharmacologic deliver: 7,654 registers
- Active compound: 2,123 registers
- Services: 145 registers
- Other services: 810 registers
- Sick leave: 6 registers
- Type of health care attentions: 2,414 registers
- Units of measurement: 34 registers

The data of the registries has been processed as follows:



In what follows, KPI baseline measurement will be provided disease by disease, i.e. a series of 10 tables, and refers to the period of 01/2015 -12/2015. Descriptive statistics of the cohorts underlying these KPIs are presented below:

Comorbidity category	Number of patients statistic is based upon	% Male	Average age
DIABETES	511,125	53.03%	69.73
CORONARY HEART DISEASE	126,526	72.84%	73.29
HEART FAILURE	90,625	67.99%	74.84
STROKE & ISCHEMIA	218,580	48.49%	76.18
PERIPHERAL VASCULAR DISEASE	65,436	70.00%	73.13
CHRONIC RENAL DISEASE	273,382	47.18%	75.55
ARTHRITIS / ARTHROSIS	309,793	34.73%	63.24
CPOD/EPOC	567,755	46.68%	61.27
DEPRESSION	475,721	29.74%	65.25

Comorbidity category	Number of patients statistic is based upon	% Male	Average age
HYPERTENSION	1,278,771	47.78%	68.39
ATRIAL FIBRILLATION	315,420	50.56%	73.23

	Patient Outcomes			Process Outcomes					Financial Outcomes	
Comorbidity category	**Mortality rate (%)**	**Average age at point of death**	**Number of days with sickness leave (per patient)**	**Number of visits to specialist (per patient)**	**Number of ER visits (per patient)**	**Number of hospitalizations (per patient)**	**Number admission to Critical Care Unit (per patient)**	**Days of hospitalization (per patient)**	**Costs of hospitalization (per patient)**	**Costs of ER visits (per day and patient)**
DIABETES	3.24	80.58	49.26	4.39	1.48	1.38	1.13	3.92	NA	€ 189.00
CORONARY HEART DISEASE	5.42	81.69	110.13	5.15	1.88	1.46	1.16	4.6	€ 8,890.45	€ 189.00
HEART FAILURE	5.06	80.9	112.24	4.88	1.85	1.44	1.15	4.31	€ 4,316.65	€ 189.00
STROKE & ISCHEMIA	5.93	83.53	64.26	4.8	1.81	1.4	1.11	4.76	€ 8,445.38	€ 189.00
PERIPHERAL VASCULAR DISEASE	5.64	80.12	111.59	5.55	1.89	1.47	1.18	4.66	€ 7,868.59	€ 189.00
CHRONIC RENAL DISEASE	5.67	83.12	48.78	4.88	1.83	1.43	1.14	4.6	NA	€ 189.00
ARTHRITIS / ARTHROSIS	1.31	79.17	40.64	4.5	1.46	1.31	1.11	3.04	NA	€ 189.00
CPOD/EPOC	2.87	80.92	42.49	4.28	1.5	1.37	1.12	3.87	€ 3,151.84	€ 189.00
DEPRESSION	3.82	82.99	49.12	4.41	1.52	1.35	1.1	3.97	NA	€ 189.00
HYPERTENSION	2.77	81.77	52.83	4.19	1.47	1.35	1.12	3.81	NA	€ 189.00
ATRIAL FIBRILLATION	5.46	82.93	47.73	4.84	1.83	1.42	1.14	4.65	NA	€ 189.00

Patient satisfaction is currently not assessed.

2.1.2. Pilot 2: Kidney Disease

The aim of this pilot is to combine advanced diagnostic data from the Charité transplant centre with data of ambulatory healthcare providers and smartphone transmitted real-time patient-level data. The intervention, driven by novel dynamic prediction models and alert systems will facilitate precision medicine and clinical decision support during post-transplant treatment. These intervention tools will allow early recognition, management and prevention of post-transplant complications, thus prolonging kidney graft survival, reducing hospitalizations and improving medication adherence.

The baseline measurement refers to the period 01/2017 – 06/2018, broken up into three periods of six months. It covers a cohort of 1,143 patients for follow up care with a median age of 49 years by transplantation:

Baseline measurement	T=0 (M0) 01/17-06/17	07/17-12/17	01/18-06/18
Financial outcomes			
NA	NA		
Process outcomes			
Total number of hospitalizations	1,299	1,459	1,378
Average length of stay	3.0 days	2.6 days	2.8 days
Average length of stay at ICU	NA	NA	NA
Total number of regular patient visits	7,164	7,178	6,572
Total number of unplanned patient visits	1,537	1,482	1,791
Patient outcomes			
Number of patients who returned to dialysis after transplantation	8	8	7
Number of deaths	13	11	17
pAcute kidney injury after transplantation:			
Number of patients within category AKI48	118	134	127
Number of patients within category AKI1	92	129	100
Number of patients within category AKI2	14	17	22
Number of patients within category AKI3	76	60	88
Proteinuria:			
Number of patients with proteinuria <500	727	826	725
Number of patients with proteinuria 500-1000	75	98	87
Number of patients with proteinuria >1000	61	78	83
Renal function eGFR:			
Number of patients with eGFR >60	227	278	271
Number of patients with eGFR 45-60	216	243	222
Number of patients with eGFR 30-45	240	252	243
Number of patients with eGFR <30	258	250	255
Number of rejections	34	22	28

Baseline measurement	T=0 (M0) 01/17-06/17	07/17-12/17	01/18-06/18
Patient satisfaction			
NA	NA		

Patient satisfaction is currently not assessed. While it is planned to analyse financial outcomes, the required analyses have not yet been implemented.

2.1.3. Pilot 3: Diabetes

This pilot aims to reduce the number of visits of pregnant women who suffer from chronic diseases, with a focus on diabetes, to antenatal and diabetic care units through Remote Patient Monitoring (RPM) thus highly reducing number of admissions and hospitalization costs while increasing patient care at home. In the retrospective part of the pilot, continuous monitoring by combining real-time-data processing and historical data analytics will be used to better understand patient health condition and predict health complications earlier. In the prospective phase, the system built in the retrospective phase will be used to remotely monitor pregnant women and generate alerts and automated recommended treatment plans to the healthcare specialists for review.

The baseline measurement refers to the period 05/2017 – 05/2018 and covers a cohort of 45 female patients (plus 22 female patients for comparative purposes from a second organisational site). Measurements will be reported per organisational site, where applicable. Patients are on average 32.6 years old (Site 2: 32.5 years) with an average BMI of 28.5 (Site 2: 30.7).

Baseline measurement	T=0 (M0)	
Financial outcomes		
Average medication cost per patient	NA	
Average cost of hospital admission	NA	
Average cost of outpatient clinic visit per patient	167.43 EUR	
Average number of work days lost per patient	2.01 days	
Process outcomes		
Average number of attendances to OP clinic (show-up rate)	84%	
Number of patients on diet control	45	22
Number of patients using insulin at least once during pregnancy	5	14
Number of patients on metformin at least once during pregnancy	0	12
Number of hospital admissions	NA	
Average length of stay in the hospital	NA	
Number of day care admissions	NA	
Patient outcomes		
Average gestational wage	3.264 kg	3.061 kg
NICU admission rate	4.44%	18.18%
Hypoglycemic rate	NA	
Macrosomia rate	4.44%	9.52%

Baseline measurement	T=0 (M0)	
Patient satisfaction		
NA	NA	

Since appointments to outpatient clinics last on average half a day, work days lost per patient are reported on the assumption that patients take half a day off, i.e. the figure is therefore a lower bound for the average number of work days lost. The costs of outpatient clinic visits include the direct costs associated with a patient's clinic visit, i.e. from midwife care up until nutrition costs. It is expected that during the course of the project, financial outcomes can be estimated more precisely and that data for the KPIs that are currently not available (NA) can be collected prospectively.

Measures for patient satisfaction will be collected using a patient satisfaction survey that is currently being developed and not yet implemented.

2.1.4. Pilot 4: COPD/ Asthma

The pilot seeks to develop predictive models of acute exacerbations of COPD from real-time patient relevant data using mobile and web enabled platforms MY COPD and MY Asthma. The models will enable patients and health care services to move from a reactive to proactive approach to care and targeting limited resources to patients who need them in a timely manner, while intervening early with treatment, preventing hospitalisation and use of emergency care while improving clinical outcomes for a national cohort of patients in the UK.

The baseline measurement refers to the period 1/10/2017 – 31/3/2018 and covers a cohort of 337 patients. Descriptive statistics of the patient cohort will become available retrospectively.

Baseline measurement	T=0 (M0)
Financial outcomes	
NA	NA
Process outcomes	
Average number of COPD hospitalizations	NA
Average number of COPD bed days	NA
Average number of primary care contacts	NA
Average number of planned secondary care contacts	NA
Average number of emergency secondary care contacts	NA
Average number of secondary care admissions (without COPD restriction)	NA
Average prescription rate	NA
Average daily uptake of pulmonary Rehab, indicated by the number of exercise videos each patient plays on the app per day	0.061
Patient outcomes	
Average daily exacerbation frequency	
• Assuming that every patient always reports exacerbations	0.012
• Assuming that accessing the app is independent of exacerbation events	0.087
Adherence to inhaled medication	NA

Baseline measurement	T=0 (M0)
Patient satisfaction	
Average Score COPD Assessment test (Score range: [0-40])	17.11
Number of patients using the app versus the number of licences sold	0.032
Average frequency of accessing the app per day	0.128
Average of the maximum days patients did not use the app	56.99

Please note that due to the early stage data extraction and collation for the purposes of the pilot, details and values for some of these KPI baseline measurements are subject to change and correction.

It is expected that during the course of the project, individual cost of care can be monetarily quantified leading to estimates of financial outcomes. These costs of care will be based on process outcomes and it is expected that data for the KPIs that are currently not available (NA) can be collected prospectively.

2.1.5. Pilot 5: Heart failure

This pilot focusses on introducing personalized healthcare concepts to the benefit of patients with heart failure. The baseline measurement refers to the period 01/2015 – 03/2018 and covers a cohort of 1,000 heart failure patients with a median age of 54.5 years, 59% males. The cohort represents a subset of heart failure patients listed in the pilot partner's insurance database. Heart failure patients were included if they were alive on 1 Jan 2015, between 18 and 80 years and if they had a chronic heart failure insurance claim at least once between 2012 - 2014.Subsequent measurements will be based on all heart failure patients in the database (and potentially additional databases) and inclusion criteria will be modified if required.

Baseline measurement	T=0 (M0)
Financial outcomes	
Cost of care of inpatient admission	NA
Cost of consults/ outpatient appointments	NA
Cost for medication	NA
Process outcomes	
Hospitalizations, heart-failure related	
Number of patients hospitalized	107
Number of hospital admissions	207
Average length of stay in the hospital	9.9 days
Average number of days to admission since Jan 1, 2015	396 days
Hospitalizations, cardiology-related	
Number of patients hospitalized	247
Number of hospital admissions	495
Average length of stay in the hospital	8.0 days
Average number of days to admission since Jan 1, 2015	418 days
Hospitalization, no restrictions	

Baseline measurement	T=0 (M0)
Number of patients hospitalized	506
Number of hospital admissions	1,279
Average length of stay in the hospital	9.3 days
Average number of days to admission since Jan 1, 2015	379 days
Patient outcomes	
Overall mortality rate	18.4%
Mortality rate for patient with at least one HF-related hospital admission	46%
Mortality rate for patient with at least one cardiology- related hospital admission	30%
Mortality rate for patient with at least one hospital admission	27%
Grip strength	NA
Severity of heart failure	NA
Six minute walk test	NA
Patient satisfaction	
EQ-5D	NA

Measures for patient satisfaction will be collected using a patient satisfaction survey that is not yet implemented. The same holds for parts of the patient and financial outcomes – measures to collect this data have not yet been implemented and this data will become available prospectively.

2.2. Baseline measurement for WP 3 Oncology

This work package consists of three pilots that target cancer types. All pilots have the aim to demonstrate the value and impact of big data collection on clinical decision making for different cancer types.

2.2.1. Pilot 6: Prostate cancer

The aim of this pilot is to demonstrate the impact of big data technologies on accelerating the move from volume to value-based health care (VBHC). To prove this impact, a Clinical Decision Support (CDS) system with the working title miProstate is being designed and will be implemented at Karolinska University Hospital. By use of miProstate, big healthcare data from different medical domains (urology, radiology, pathology, etc.) relevant in prostate cancer diagnostics will be combined into a single IT system and integrated with available financial data on diagnostic and treatment procedures.

The baseline measurement refers to the period 01/2016 – 12/2017 and covers a cohort of 861 patients:

Baseline measurement	T=0 (M0)
Financial outcomes	
Average cost per patient	EUR 10.079,39
Projected cost of care over ten years	NA
Process outcomes	

Baseline measurement	T=0 (M0)
Staff satisfaction	NA
Response frequency for patient-reported outcome measures (PROM)	41,4%
Number of hospital visits	7,2
Patient outcomes	
Frequency of post-surgical tumour positive resection margins (PSM)	35,7%
Frequency of urine incontinence pad use after prostatectomy	NA
Frequency of sexual dysfunction after prostatectomy	NA
Efficiency and quality of multidisciplinary therapy discussion (MDT conference)	NA
Efficiency in quality reporting to national prostate cancer registry	NA
Patient satisfaction	
Urinary function	NA
Sexual function	NA

The financial outcomes-measure 'projected cost of care over ten years' is currently being developed. This complex measure requires considerable modelling, but can be estimated ex-post. Measures for staff satisfaction will be collected using a staff satisfaction survey that is not yet implemented. The same holds for parts of the patient outcomes and patient satisfactions – measures to collect this data have not yet been implemented. In this case, this is due to the backward looking nature of these KPI's, which have a 24+ months time-lag.

2.2.2. Pilot 7: Lung cancer

The aim of this pilot is to improve the management of patients with cancer during their treatment, follow-up and during their last period of life through Big Data in order to improve not only their experience and satisfaction (their own and their family's / caregivers), and main outcomes, but also save substantial costs to the healthcare system. The suboptimal management of cancer patients is to blame for the majority of the generated costs.

The baseline measurement refers to the period 01/2017 – 12/2017 and covers a cohort of 944 patients:

Baseline measurement	T=0 (M0)
Financial outcomes	
Average cost per patient – total in-patient process	EUR 3.089,54
Process outcomes	
Length of hospital stay	7.72 days
Number of admissions ER	N/A
Number of unscheduled visits to hospital	N/A
Identification of people at risk of developing lung cancer	N/A
Patient outcomes	
Toxicities in patients with comorbidities	45%

Baseline measurement	T=0 (M0)
Patient satisfaction	
Patient satisfaction - feeling informed	NA

The financial outcomes KPIs consist of the average cost per patient (for the entire inpatient process), per patient. This measure is based on an improved calculation method within the hospital, resulting in a lower (more accurate) cost estimation. Originally, financial outcomes were also to be measured with a projected cost of care (over ten years) KPI, but this seemed less relevant (due to noise-inducing factors, outside of the scope of this pilot, such as medication pricing). Two of the process outcomes (i.e.: number of admissions to ER and number of unscheduled visits to hospital) are currently being developed with the hospital's admission and coding service. These numbers will be available in September 2018. Baseline measurement for the KPI Identification of people at risk of developing lung cancer is not feasible, since the identification is an outcome of the pilot, and currently not being measured. We expect this KPI to improve over time, once the pilot's model is implemented.

The patient outcomes and satisfaction measures are being developed and refined. Currently, toxicity-measurement is based on historical data from clinical trials in related situations, with the same treatment. After implementation of the pilot, this KPI will be based on actual measures within the cohort.

2.2.3. Pilot 8: Breast cancer

The purpose of this pilot is to develop a system that uses deep learning algorithms for big data analytics of multi-modal imaging and clinical data. This aims to improve outcomes and reduce costs in neoadjuvant chemotherapy of breast cancer treatment. Specifically, this pilot aims to create multi-modal pipelines for the prediction of response to neoadjuvant chemotherapy, the prediction of best neo-adjuvant protocol for the specific patient, and the prediction of cohorts for clinical trials towards next generation therapies.

Baseline measurement	T=0 (M0)
Financial outcomes	
Projected cost of care over ten years	EUR 19.726,15
Projected cost at CUR - treatment	EUR 13.650,5
Projected cost at CUR - adverse effects	EUR 10.706
Process outcomes	
Pathologic complete response	19,20%
Patient outcomes	
Projected mortality over five years	10,60%
Patient satisfaction	
Internal survey of patient satisfaction	96%

As a process measure, pCR (pathologic complete response, or the absence of invasive disease) is used as a way of measuring a positive outcome. This measure replaces the false-positive/negative rates from D3.1, which were not feasible to collect.

As a patient outcome, the mortality is measured at 5 years (instead of 10 years as proposed in D3.1), as these survival rates were already available.

2.3. Baseline measurement for WP 4 Industrialization Healthcare Services

This work package consists of four pilots that address innovations in the healthcare services industries. These pilots aim to demonstrate the value and impact of big data collection on the management and organization of time critical workflows within a hospital setting.

2.3.1. Pilot 9: Hyper acute workflows: Stroke management

This pilot aims to improve outcomes and thereby reduce overall cost of hyper-acute carepaths (stroke and sepsis) by using Big Data. This will be used to identify and remove bottlenecks in the time-critical, hyper-acute stages of the workflow. The pilot study will monitor the current practices associated with stroke and sepsis care at the Emergency Department(s) of the Elizabeth Tweesteden Ziekenhuis (ETZ), and implement resulting measures in order to fulfil the International Scientific Guidelines, which have established strict time periods for the recognition and initial management.

For this purpose, two methods will be combined. Firstly, retrospective data analysis will be applied on existing EMR data over several years to map current workflows as far as possible. Secondly, Real-Time Localization Systems (RTLS) will be installed in the emergency department(s), to measure workflow timings based on accurate, real-time location data.

Currently, the pilot is awaiting ethical approval. After this, the baseline data will be transferred.

2.3.2. Pilot 10: Hyper acute workflows: Sepsis management

Sepsis is a worldwide pathology with time-dependent outcomes associated with high health care costs, morbidity and mortality. The currently implemented data management system is not capable of identifying unnecessary time delays, bottlenecks and other weaknesses in the current workflow for sepsis patient management. Consequently, a Real Time Localization System (RTLS) will be deployed at the Emergency Department of Hospital Clínico-INCLIVA in Valencia to monitor throughout one year the current practices and compare them with International Scientific Guidelines. Depending on bottlenecks identified, and intervention will be introduced, and the RTLS system will subsequently be used to measure the post-intervention KPI improvements quantitatively.

For this purpose, two methods will be combined. Firstly, retrospective data analysis will be applied on existing EMR data over several years to map current workflows as far as possible. Secondly, Real-Time Localization Systems (RTLS) will be installed in the emergency department(s), to measure workflow timings based on accurate, real-time location data.

The baseline measurement refers to the period 10/2017 – 03/2018 and covers a cohort of 245 patients.

KPI Data Exchange template - Pilot 10 – Sepsis		**T=0 (M0)**
Financial outcomes		
Time between arrival of patient at ED and the final departure from the ED (RTLS) * estimated costs of department/hour	EUR	
Time between arrival of patient at ED and the final departure from the ED (EMR) * estimated costs of department/hour	EUR	189
Length of stay in the ICU or other department in hours times	EUR	

KPI Data Exchange template - Pilot 10 – Sepsis		T=0 (M0)
the average total (RTLS)		
Length of stay in the ICU or other department in hours times the average total (EMR)	EUR	7793
Process outcomes		
Time between arrival of the patient at ED and start of diagnosis acts	Minutes (RTLS)	
Time between arrival of the patient at ED and start of diagnosis acts	Minutes (EMR)	9,21
Time between arrival of patient at ED and first contact with healthcare professional	Minutes (RTLS)	
Time between arrival of patient at ED and first contact with healthcare professional	Minutes (EMR)	9,21
Time between arrival and completing diagnosis, based on the lab tests and other info	Minutes (RTLS)	
Time between arrival and completing diagnosis, based on the lab tests and other info	Minutes (EMR)	79,49
Time between arrival of patient at ED and start of treatment measures (typically medication)	Minutes (RTLS)	
Time between arrival of patient at ED and start of treatment measures (typically medication)	Minutes (EMR)	138,66
Time between arrival of patient at ED and the final departure from the ED.	Minutes (RTLS)	
Time between arrival of patient at ED and the final departure from the ED	Minutes (EMR)	432,78
Patient outcomes		
In-hospital mortality rate of sepsis patients	Percentage	43
28-day mortality rate of sepsis patients	Percentage	12
Patient satisfaction		
...		

The RTLS system is not yet in place, thus the KPIs are currently measured with the EMR system.

2.3.3. Pilot 11: Asset management

Hospitals employ expensive medical equipment. This pilot aims to make the process of finding and managing mobile medical equipment (assets) within a hospital more efficient. Productivity will be improved by ensuring that staff waste less time looking for equipment and a hospital utilizes its mobile assets more cost effectively, e.g. by reducing unnecessary equipment, distributing and/or scheduling usage. This will be performed by using a Real-Time Big Data analytics solution that will receive streaming data from a Real-Time Locating System (RTLS) to track mobile assets and possibly selected staff and patients. The RTLS technology includes infrared and radio frequency-enabled tags that are placed on any entities which need to be tracked. The Big Data solution will combine RTLS data with other data sources (e.g. machine logs, maintenance schedules and other planning systems) in order to automatically identify sub-optimal equipment usage patterns. This information can then be used by administrators to

run their departments more efficiently, by allowing them to make real-time decisions as well as design improved workflows that improve patient outcomes and/or patient satisfaction.

Currently, the pilot is awaiting ethical approval. After this, the baseline data will be transferred.

2.3.4. Pilot 12: Radiology workflows

This pilot aims to reduce the time of diagnosis in radiology departments, and at the same time improve the quality of diagnosis by providing an efficient search engine for radiological data: the ContextFlow radiology image search engine. Note that here we use “image” to mean a 3D volume. Radiologists can access comparable cases, connected information, and reference cases relevant for differential diagnosis, based on visual queries in the imaging data they are reading. The increase of diagnosis efficiency, and the ability to effectively search in large data bases of medical imaging is critical, since about 30% of world-wide storage will be occupied by biomedical imaging data over the next years, with yearly more than 125 Mio CT and MR examinations performed in the EU alone. This pilot will scale a search engine for medical imaging data at the point of care across larger clinical imaging resources, in a heterogeneous field of clinical institutions.

The baseline measurement is currently based on a review of the literature, and does not refer to actual measurement within the pilot. Pilot 12 will only be doing the first experiments both with and without the tool over the next 6 months, as such experiments require a lot of effort to set up in a way to get objective and usable results, including setting up the protocols, defining tasks, and recruiting sufficient radiologists. T=1 will therefore be used as the first ‘real’ baseline. T=0 is used as a point of reference for these measures. The personnel costs to analyse one image measurement is based on the assumption that a radiologist costs €5000 per month and works 1720 hours per year – given images per hour, this can be calculated. Concerning the process outcomes, the number of images examined and reported on by a radiologist is based on radiologists in Europe spending 31 million hours to view 125 million CT/MRI images each year (based on estimates from Barmer 2011, Royal College of Radiologists 2012, and Frost & Sullivan 2011). The Inter-observer discrepancy rate in the interpretation of CT images between different radiologists is the pooled total discrepancy rate for chest CT from Wu et al (2013). For the intra-observer discrepancy, no relevant value was found in the literature.

This pilot has no direct involvement with patients. Therefore, the patient outcomes and satisfaction dimensions are not relevant for this pilot, and will not be measured.

At a later stage, we will also be measuring the KPIs when the radiologists use the tool.

Baseline measurement	**T=0 (M0)**	
Financial outcomes		
Personnel cost to analyse one image (without tool)	EUR	9
Process outcomes		
Number of images examined and reported on by a radiologist per hour (without tool)	#	4
Inter-observer discrepancy rate in the interpretation of CT images between different radiologist (without tool)	%	8,2
Intra-observer discrepancy rate in the interpretation of CT images between radiologists (without tool)	%	NA
Patient outcomes		

Baseline measurement	T=0 (M0)	
…		
Patient satisfaction		
…		

Appendix A References

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