Leveraging Financial Analytics for Healthcare Organizations in Value-Based Care Environments

Dieter Van de Craen, Daniele De Massari, Tobias Wirth, Jason Gwizdala, and Steffen Pauws

1 Introduction to Financial Analytics for Population Health Management

Almost all healthcare systems worldwide are currently struggling with rising costs and uneven quality despite numerous efforts to overcome these challenges. To bend the cost curve, healthcare systems are in a transition towards value-based healthcare [27], aiming at maximizing the value of care for the patient and reducing healthcare costs. One of the key elements is to introduce innovative payment schemes that are not based on the long-standing fee-for-service (FFS) model. In the recent past of FFS, healthcare provider organizations had the ease to send a bill to a payer for every service rendered, which hardly requires financial accounting and planning but rather creates a financial incentive to provide more services irrespective of their necessity or quality. New reimbursement, incentive, and penalty schemes make healthcare provider organizations financially accountable for their patient population which does require periodical financial planning and reporting, health plan and fee schedule negotiation with commercial and governmental insurers, internal cost optimization for in- and outpatient services, and budget reservations for provider network engagement and community outreach. Consequently, understanding financial performance, identifying opportunities for improvement, and assessing the efficacy of implemented programs are among the key needs for any healthcare provider organization that grows along the path of value-based care.

D. Van de Craen (✉) · D. De Massari · T. Wirth · S. Pauws
Philips Research, Eindhoven, The Netherlands
e-mail: dieter.van.de.craen@philips.com; daniele.de.massari@philips.com; tobias.wirth@philips.com; steffen.pauws@philips.com

J. Gwizdala
Philips Wellcentive, Alpharetta, GA, USA
e-mail: jason.gwizdala@philips.com

S. Consoli et al. (eds.), *Data Science for Healthcare*,
https://doi.org/10.1007/978-3-030-05249-2_14

1.1 Health Systems Financing

Developed countries have arranged the financing of their healthcare system in various basic forms to meet the goals for keeping a healthy population, providing care in case of sickness, and covering costs involved. Most countries have settled down to a basic arrangement of public or private providers and payers, though they have added their own variation to the basic form. In so-called Bismarck countries such as Germany, the Netherlands, and Belgium, both providers and multiple payers are private entities; they are linked to each other by various health insurance plans that are financed by employers and employees primarily through payroll deduction. In Beveridge countries such as the UK, Italy, and Spain, the government acts as a single public payer to governmentally owned providers delivering healthcare as a public service that is financed through tax payments. In countries with a National Health Insurance (NHI) such as Canada and Australia, the providers are private entities but the government acts as the single public payer with an insurance plan that is financed by a monthly premium collection. According to the OECD health statistics database, the amount spent on health per person in the USA summed to $9892 in 2016 [24]. The healthcare cost per capita in the USA is almost double the average health expenditure of comparable countries. For that reason, we will focus on the US healthcare system as an example case to introduce the methodology of population health management in the field of financial management of healthcare organizations which in turn is adaptable to other countries' healthcare systems and data governance. The USA has not settled to a single basic form of healthcare financing, but uses different ways of insurance for different parts of its population [3]:

- *Medicare* is the health insurance paid by the federal government for people over 65, certain younger people with disabilities, and people with end-stage renal disease. Medicare covers 58 million people and 20% of the total cost of care. Essentially, Medicare acts as a NHI model in the same vein as in its neighboring country Canada. Medicare is the central focus of this chapter.
- *Medicaid* is the insurance for the 68 million "vulnerable" people with low incomes and disabilities and living in care homes with no property. The criteria to qualify for Medicaid vary by state. Medicaid is partially paid by state, but supplemented by the federal government. Also, Medicaid follows a NHI model.
- The *Army or Department of Veterans Affairs* (VA) insures 18 million military personnel, veterans, and Native Americans. The VA offers basically all necessary care to its own insured and acts therefore according to a Beveridge model.
- *Private insurance* is in place for working people through their employer by a health plan (156 million Americans) or for the 22 million people who have and pay their own health insurance (the non-group market). The private insurance is run like a Bismarck model.
- At present, around 28 million of the 320 million Americans are *uninsured* (about 9%).

1.2 Medical Claims Data

Generally, medical claims data refers to the information within medical billing claims forms. These forms are submitted by medical providers to health insurers for payment and contain valuable information such as procedure codes and their associated diagnosis codes. In order to support healthcare organizations in monitoring their financial performance, it is a necessity to realize software that processes medical claims data and computes financial key performance indicators (KPIs). In this section we provide an example on how to analyze medical claims data. We choose an Accountable Care Organization participating in a Medicare Shared Savings Program to describe necessary steps in the pre-processing of claims data and computation of financial KPIs.

This type of medical claims data is typically not freely available for research. However, notable examples of curated US healthcare administrative data sources are the Healthcare Cost and Utilization Project (HCUP) [14] and the Research Data Assistance Center (ResDAC) [29]. HCUP is a source of hospital care data, including information on inpatient stays, ambulatory surgery and services visits, and emergency department encounters which can be used to study healthcare delivery and patient outcomes over time, and at the national, regional, state, and community levels. Via ResDAC researchers can access the Centers for Medicare and Medicaid Services (CMS) Medicare and Medicaid claims data.

1.2.1 Medicare Shared Savings Program

CMS established the Medicare Shared Savings Program (MSSP) on January 1, 2012, as required by the Affordable Care Act [11]. The MSSP is a voluntary program designed to provide better care for patients, better health for the communities, and lower costs through improvements in the healthcare system. Participating entities, referred to as Medicare Accountable Care Organizations (ACOs), that meet quality and performance standards, are eligible to receive payments for shared savings. An ACO is a group of healthcare providers, such as physicians and hospitals, that work together to manage and coordinate care for a group of patients across the entire spectrum of care for those patients and accept responsibility for the quality and cost of that care. Medicare ACOs may choose to participate in different tracks which differ in requirements and have either one-sided or two-sided financial risk. Under the one-sided model (Track 1), an ACO may receive shared savings if it meets the applicable requirements, but it will not be liable for shared losses. Under the two-sided models (Track 1+, Track 2, and Track 3), the ACO may share both savings and losses. For a comparison of the different tracks, we refer to [9].

In the remainder of this chapter, we will assume that we are operating under the conditions of a MSSP Track 1. It must be noted that most risk-based contracts tend to have similar conditions and as such the descriptions will be valid for these types

of contracts as well. However, different benchmarking methods and data formats will apply and must be handled in order to make the descriptions applicable.

1.2.2 Medical Claims Data: The CCLF Format

ACOs receive from CMS aggregated information on their assigned population and financial performance at the start of the agreement period and quarterly during the performance year, as well as following the conclusion of each performance year. Next to this, CMS provides ACOs with monthly Claim and Claim Line Feed (CCLF) data as beneficiary-identifiable claims data to assist ACOs in enabling their practitioners to better coordinate and manage care strategies towards the individual beneficiaries who may ultimately be assigned to them. The CCLF data provides monthly data feeds to each ACO, including:

- *Medicare Part A* (Hospital Insurance) *and B* (for Supplemental Medical Insurance) data for the appropriate beneficiaries who have not opted out of data sharing. Data related to substance abuse claims and diagnoses are not included in the feeds.
- *Medicare Part D* data (Pharmaceuticals) is provided for individuals enrolled in a private part D plan.

The CCLF data is an important supplement to an ACO's own data as the CCLF also contains claims data for services received by the ACO beneficiaries but delivered by providers not participating in the ACO. This gives ACOs a broader picture of the services each beneficiary in the CCLF files has received from Medicare providers. However, the CCLF data cannot be used as a source of truth as there are a number of shortcomings in the data (for a detailed description about the limitations, we refer to [18]). As a result, the CCLF data only allows to create similar but not exactly the same numbers as CMS.

CMS provides the ACO with nine separate CCLF files; see Table 1 for an overview.

Table 1 Claim files

Group	Code	Name
Part A (patient's hospital and institutional related activity)	CCLF1	Claims header file
	CCLF2	Claims revenue center detail file
	CCLF3	Procedure code file
	CCLF4	Diagnosis code file
Part B (services delivered by physicians, practitioners, and suppliers)	CCLF5	Physician file
	CCLF6	Durable medical equipment (DME) file
Part D	CCLF7	Pharmaceutical prescriptions
Beneficiary data	CCLF 8	Beneficiary demographics file
	CCLF9	Beneficiary XREF (cross reference) file

1.2.3 ACO Membership Files: The QASSGN Files

Crucial for an ACO is to know who are its patients or beneficiaries. Financial performance in terms of number, cost, and quality of services offered and reimbursements received depend on the patient population an ACO is held accountable for. Beneficiary attribution lists are required to generate quarterly reports on financial and quality performance; it determines whether an ACO can share in savings or losses in Medicare programs.

For ACOs in MSSP Tracks 1 and 2, beneficiary assignment is determined retrospectively at the end of the year for each benchmark and performance year. For these ACOs, Medicare provides each quarter so-called QASSGN files listing the attributed and assignable beneficiaries to the ACO. Variation in retrospectively assigned beneficiaries throughout the year can be about 20 to 30%. Likewise, it is common for the final attributions to vary with the same amount from year to year. To make up these lists, CMS uses a two-step attribution process to associate beneficiaries with providers [7]. In the first step, a beneficiary is assigned to the ACO whose primary care physician or non-physician practitioner has rendered more primary care services than all other ACOs to the selected beneficiary. The second step applies for those beneficiaries who have not received any primary care services of an ACO and is similar to the first step but rather looks at services rendered by specialist physicians. For Track 1+ and Track 3 ACOs, beneficiary assignment is determined prospectively prior to the start of each benchmark and performance year, and hence it is much easier for these ACOs to keep track of their population.

1.2.4 Physician Roster File

ACO lists their affiliated organizations and physicians in an ACO roster file or provider hierarchies in which provider organizations are listed by their National Provider Identification (NPI) and legal name. This data is needed to identify those organizations and physicians that are referred to in the claims record as part of the ACO network or as out-of-network.

1.3 Previous Work

Previous research studies examining and understanding the US healthcare system through analyzing healthcare administrative or insurance claims data are numerous. They are primarily focused on unraveling health disparities in population, understanding health risk factors, curbing rising costs, and identifying the most effective treatments, the best providers, and the most efficient health plans within a healthcare delivery system for a population [17]. These studies have resulted in profound insights in healthcare practice. Already in 1973, it led to findings on wide variations in rates of costly medical treatments in similar patient populations [34].

Some recent studies report on the evidence on favorable outcome of value-based care mechanisms in healthcare finance [19], the variation in spending across physicians [31], or the drivers of healthcare spending, utilization, and health outcome in the USA compared to other high-income countries [25].

2 Healthcare Financial Analytics on Medicare Claims Data

In the second part of this chapter, we will introduce a basic framework for healthcare data scientists to help healthcare organizations achieve financial success in an accountable or value-based care environment. The reader will learn the key components of translating clinical and financial information contained in raw claims data into actionable insights for financial performance dashboards that inform C-suite executives on decision-making and the development of best practices. The prerequisite for getting started with financial analytics is to identify final action claims from the raw claim feed which the payer for an insured patient population shares with the healthcare organization. Though this step may need to be adapted to other sources of healthcare insurance claims, we exemplify the pre-processing by Medicare data. We describe how KPIs can help healthcare organizations participating in risk-based contracts identify areas of concern across the three main domains of assigned patient population, clinical care and patient utilization, and financial performance. We then explain how to construct selected high-level KPIs, what specific use case each KPI targets and what data is needed to measure performance, and finally how to visualize the output on C-level dashboards. The final section focuses on selected drill downs that allow moving from the high-level summary information of a KPI towards more actionable information by focusing on specific attributes. Finally, the healthcare data scientist is equipped with the skills to leverage population health management techniques to monitor performance and identify areas of improvement for defined use cases with impact on quality, revenue, and satisfaction of patients and healthcare professionals.

2.1 Curated Pre-processing of Claims Data

Monthly CCLF data feeds, beneficiary attribution lists, and physician roster files need to be ingested into a claims data pre-processing pipeline for data linkage and cleansing. In general, it entails appending claims records across feeds, grouping claims for the same beneficiary and service, removing duplicate claims, validating primary key prerequisites, identifying final claims, attributing beneficiaries to an ACO, and selecting a time period for reporting.

When handling monthly CCLF data feeds in a claims pre-processing pipeline, a number of attention points need to be taken into account. The following list provides an overview of the key attention points:

- *Benchmark set*. The very first data feed is a benchmark feed containing CCLF files providing an ACO with data back to 1 year prior to the start of its agreement period for each beneficiary;
- *Update set*. The monthly updates represent claims during the prior month. These should be appended to previously received data feeds;
- *Time lag*. The feeds are provided monthly and lag by roughly 45 days. This means that a feed from June contains data through the end of April;
- *Claim lag*. Every feed will have claims which are several months old at various stages of payment. This means that historical numbers change from month to month and a specific claims run-out time is selected for the generation of financial reports;
- *Claim availability*. Not all claims are included in the CCLFs as CMS does not share any claims that identify drug and alcohol treatment information and beneficiaries may have opted out for data sharing.
- *Beneficiary attribution*. As said, attributions or assignments are sent from up to six times per year. First the prospective attribution for the coming year is sent to be followed by four quarterly attributions and the final attribution. The latter is provided along with cost savings and performance results.

Specific software resilience measures need to be incorporated in the pipeline, as CCLF and QASSGN formats happen to change over time or have different specifications from various insurance organizations when handling commercial value-based contracts. For instance, the CCLF specification is currently at version 18.0 (published on January 25, 2017) [1]. New versions are not published at regular intervals. Changes to the QASSGN and CCLF file layout and codes used will impact the validity of our data model and algorithms. For the QASSGN files, the specification is however part of the provided files. Next to this, an ACO will need to provide an overview of the participants in their network. This provider roster file can be customer specific and also change over time. As a result of these issues, a number of sanity checks will be necessary when these types of files are received to identify and accommodate for the inconsistencies detected.

Next to these attention points, a number of practical challenges need to be taken into account with respect to CCLF claims pre-processing:

- *History*. A claim history spans multiple months: from billing to settlement through negotiation. Each change on a claim is reported in the monthly feed when the change occurred; therefore, one cannot determine a priori at any given moment in time if other changes will (or not) occur for the claim under investigation. As data feeds come in on a monthly basis, history of every claim needs to be re-created by appending claim records from successive feeds and indexing each record with its originating feed;

- *Matching Health Insurance Claim Number*. A HICN is a Medicare beneficiary's identification number consisting of a 9-digit Social Security Number (SSN) followed by an alpha or alphanumeric suffix containing Beneficiary Identification Code (BIC). However, retirement, disablement, change in marriage status, and age or death of a spouse can change a HICN in its BIC. Different HICN that actually refer to the same beneficiaries need to be identified and updated for all monthly and historic claim records;
- *Claim Duplicate Removal*. Exact duplicates of claims records identified during pre-processing should be removed based on all original columns, hence excluding the columns added during pre-processing;
- *Duplicate primary keys*. Duplicated primary keys are found in different and successive CCLF files, which corrupt the data integrity of the CCLF data model instance. Duplicated keys need to be resolved;
- *Final Claim Identification*. A history chain of claims can consist of multiple original, cancellation, and adjustment claims. Hence a process needs to be followed to determine the final claim which refers to the actual settlement on payment or rejection or the end of a care episode. There are several methods to identify a final claim, though a debit/credit adjustment method has been recommended by CMS which helps understand the net payment of the claim chain [1].

2.2 Required Linkage with External Data and Information Sources

Besides the CCLF data feeds, QASSGN, and provider roster file, the pre-processing pipeline and performance calculations require a number of external data and information sources which are regularly updated. Table 2 provides an overview of these sources.

2.3 Methods of Financial Performance Assessment in Total Cost, Utilization, and Patient Leakage

A few financial KPIs are fundamental for ACOs, especially for their C-suite executives (e.g., chief financial officer) or financial managers, to keep track of their organization's financial performance. Based on knowledge from financial field experts and information extracted from financial reports, we arrived at the following minimal set of eight measures: beneficiary count measures, total and per member per month (PMPM) cost measures, admission measures, avoidable admission measures, ED visit measures, avoidable ED visit measures, readmission measures, and patient leakage measures.

Table 2 External data and information sources

Name	Description
ICD10	The International Statistical Classification of Diseases (ICD) and Related Health Problems is an internationally uniform and standard list of medical conditions [35].
CCS	Clinical Classifications Software is a diagnosis and procedure categorization scheme that can be used to analyze data on diagnoses and procedures [16].
PQI	Prevention Quality Indicators are a set of measures that can be used with hospital inpatient discharge data to identify "ambulatory care sensitive conditions" (ACSCs). These ACSCs are conditions for which good outpatient care can potentially prevent the need for hospitalization [28].
Readmission rule	A hospital readmission is an episode when a patient who had been discharged from a hospital after an (index) admission is admitted again within a specified time interval [10].
NYU alg.	The NYU algorithm for ED visit classification assesses the level of emergency department (ED) use in the general population and its association with hospital admission and mortality [4, 5, 23].
MS-DRGs	The Medicare Severity Diagnosis Related Groups is a system for classifying a Medicare patient's hospital stay into clinically similar groups in order to facilitate payment of services [8].

It is key to have a common understanding and agreement on these KPI definitions to allow for valid comparison over time and across ACOs. Therefore, we have, if available, settled on CMS-endorsed definitions for the KPIs as these CMS definitions are well documented and, in general, well accepted and used in the healthcare domain.

2.3.1 KPI 1: Beneficiary Count

Especially for ACOs participating in a program with retrospective beneficiary assignment such as MSSP Tracks 1 and 2, it is crucial to track their currently attributed and attributable beneficiaries as these sets can change substantially over time. For all ACOs it is key to understand their financial performance in terms of number, cost, and quality of services offered and reimbursements received for their attributed population.

We use the following definitions for beneficiary count indicators:

- Attributed beneficiaries: the number of beneficiaries attributed to the ACO.
- Assignable (or potentially attributed) beneficiaries to the ACO.
- Total eligible member months: the sum of the number of Medicare eligible beneficiaries per month over a pre-selected time period.
- Total eligible member years: total eligible member months divided by 12.
- Number of deaths of attributed patients: number of beneficiaries deceased in the selected time period.

2.3.2 KPI 2: Total and PMPM Cost (Parts A and B)

If an organization is financially responsible for a group of beneficiaries, it is crucial for the organization to track the cost of care incurred by the attributed population. Besides the traditional fee-for-service model, several emerging new payment models (e.g., one-sided or two-sided shared savings programs, partial or full capitation, global budget) are being adopted that implement to a different degree value-based reimbursement strategies. Depending on the specific value-based or risk-shared contract, at the end of each financial year, an organization will receive incentives, penalties, shared savings, or shared losses depending on, among other criteria, the comparison between the total cost of care incurred by the attributed population and a specific benchmark. As the total cost of care focuses on the entire population, the PMPM cost is used to track the average cost spent per beneficiary in a month which can be used to identify high-cost beneficiaries, for instance. A cost-saving opportunity exists by improving the coordination of care among specialists or designing tailored intervention programs for reducing under- and over-treatment of these high-cost beneficiaries. This opportunity can be significant as typically a relatively small group of the top 5% of high-cost beneficiaries make up about 50% of the total spending [20].

We use the following definitions for the cost indicators:

- The total cost of care is considered as the sum of all the healthcare expenses incurred by the beneficiaries attributed to a specific organization within a specific period (e.g., fiscal year). The current definition comprises Part A and Part B claims.
- The PMPM is equal to the total cost of care for the selected time period divided by the total eligible member months.

2.3.3 KPI 3: Admission

Admissions are the largest cost factor for Medicare. Currently, the average paid amount by Medicare for an admission is exceeding $12k [21]. With 10 million annual inpatient admissions US-wide, the annual cost of inpatient admission sums up to more than 100 billion dollars. For any healthcare delivery system, it is important to get insights in the underlying clinical diagnosis for an admission, most common procedures for surgical admissions, inpatient hospitalizations admitted via the ED, and certainly avoidable admissions and readmissions.

We use the following definitions for the admission indicator:

- An admission is defined as any patient admitted to a hospital indicated by an inpatient claim. Such admissions are identified by claim type code (“IJCLM_TYPE_CD”) of the Part A header CCLF1 file: 60 for an Inpatient claim and 61 for an Inpatient “Full-Encounter” claim;

- Total number of hospital admissions is counted from claims of the following care units: Short-Term Stay Hospital, Long-Term Stay Hospital, Rehabilitation Hospital or Unit, and Psychiatric Hospital or Unit;
- The length of stay (LoS) is defined as the difference in days between the claim through (CLM_THR_DT, hospital discharge date) and claim from (CLM_FROM_DT, hospital admission date) dates as given in the CCLF1 Part A header file. In case the claim from and through dates are the same, the admission is assigned with a LoS of 1 day.

2.3.4 KPI 4: ED Visits

The increase of emergency department utilization is alarming in the USA; in 2011, over 131 million ED visits took place, and that increased to 141 million in 2014 [22, 33]. On a yearly basis, 45 ED visits happen per 100 US citizens. About half of the inpatient admissions originate from an ED visit. Patients who cannot afford the cost of a normal primary care visit, as they might be uninsured, or who are unwilling to wait for care often consult the ED for primary care. In particular, ED visits are the only readily available care for the uninsured [13, 30]. For a good insight in ED utilization, we refer to two types of ED visits:

- *treat-and-release outpatient ED visits* which are ED visits resulting in discharge at the same day, which includes patients who are sent home possibly after stabilization, transferred to another hospital;
- *inpatient ED admissions* which are ED visits resulting in an admission to the same hospital.

For identifying ED visits from Medicare claims data, we use the CMS Research Data Assistance Center (ResDAC) method. There are about four different operational definitions of ED visits from claims data in use [32]. They indeed produce different estimates on hospital-based emergency care, calling for the need of a standard method of estimating number and cost of ED visits from claims data for consistent reporting and comparison. Adjustment of ED visit identification from claims data is needed if additional care sites such as freestanding EDs or urgent care centers with a different billing system—for example, via physician claims—getting increased utilization.

We define *treat-and-release ED visits* as outpatient ED visits. Such an ED visit is identified from outpatient claims using claim type code (CLM_TYPE_CD) equal to “40” given in the CCLF1 Part A header file. The Revenue Center Code for emergency department, to which a claim charge is billed, is identified by the codes 0450–0459 or 0981 in the CCLF 2 field (CLM_LINE_PROD_REV_CTR_CD). A treat-and-release ED visit is classified on its level of emergency by the NYU algorithm by assigning a probability for each possible category based on the primary diagnosis.

ED inpatient admissions are ED visits that lead to hospitalizations on the same day. They are also identified by the revenue codes listed above in the CCLF 2

field (CLM_LINE_PROD_REV_CTR_CD). These codes flag utilization of services from the ED department and indicate that the patient was admitted through the ED.

Note that no cost unit can be assigned to the ED utilization in case of an ED admission because any cost is already absorbed in the bundled DRG bill for the hospital admission.

Total ED utilization is defined as the sum of treat-and-release ED visits and ED inpatient admissions.

2.3.5 KPI 5: Readmissions

In the USA, reimbursement of a medical treatment has started to be linked to the quality of the treatment delivered by a hospital. In particular for six medical conditions, hospitals are penalized by withholding up to 3% of Medicare reimbursement if they have a higher-than-expected 30-day readmission statistic. For a US hospital or an ACO, it is therefore key to focus on the readmission reduction programs for not losing revenues. The event of a readmission is therefore costly but sometimes a potential preventable event. Some readmissions are unavoidable and result from inevitable progression of disease or worsening of chronic conditions or are simply planned readmissions. However, readmissions may also result from poor quality of care or inadequate transitional care. Transitional care includes effective discharge planning, transfer of information at the time of discharge, patient assessment and education, and coordination of care and monitoring in the post-discharge period.

We count readmissions as unplanned all-cause 30-day readmission as defined by CMS [2]. It is based on the Yale hospital wide readmission measure used for quality performance standard ACO #8 [2]. According to this definition, a readmission is a subsequent inpatient admission (to short-stay acute-care or critical access hospitals) which occurs within 30 days of the discharge date of an eligible index admission. Because planned readmissions are not a signal of quality of care, we do not count planned or potentially planned readmissions. The measure uses an algorithm to identify "planned readmissions" in claims data that will not count as readmissions in the measure.

The readmission rate is the percentage of index admissions that are readmitted within 30 days of discharge. So, the denominator is the number of index admissions discharged. To arrive at a readmission rate, we can either use a prospective or retrospective method. In the prospective method, we count the number of index admissions that had an unplanned readmission for any cause within 30 days; it lacks an accurate estimate for the last running month. In the retrospective method, we count the actual number of unplanned readmissions; it requires a 1-month prior period from the CCLF feeds.

A readmission may in turn serve as an index admission for a next readmission, if it meets particular eligibility criteria. This allows capturing recurrent (re)admissions events for the same patient, whether at the same hospital or another.

There are various eligibility criteria whether or not an admission can act as an index admission in the denominator of the measure. Admissions are excluded as an index admission if:

- no post-discharge data is available;
- discharge happened against medical advice;
- cancer, psychiatric, or a rehab treatment took place;
- patients were younger than 65 years of age;
- an in-hospital death happened;
- a transfer to another acute-care facility upon discharge or to another hospital is within 1 day;
- multiple hospitalizations within single acute episode of care took place.

Likewise, admissions can act as a readmission, if they are unplanned admissions to a Short-Term (General and Specialty) Hospital or a Critical Access Hospital, as identified by the four last digits in their CMS Certification Number: 0001–0879 for a short-term hospital and 1300–1399 for a critical access hospital. A few specific types of care are always considered planned (e.g., obstetrical delivery, transplant surgery, chemotherapy, radiotherapy, immunotherapy, rehabilitation). A readmission is excluded if it includes a procedure that is potentially planned. Readmissions for acute illness or for complications of care are always unplanned. Admissions to one of the eleveen CMS-indicated cancer hospitals exempted for a Prospective Payment System are excluded to count as a readmission [22].

2.3.6 KPI 6: Probable Avoidable ED Visits (Not Leading to Admission)

As said, 45 ED visits happen per 100 US citizens amounting to a staggering number of 141 million ED visits in 2014 [22]. An ED is the most expensive healthcare resource in a hospital making overutilization and inappropriate use of the ED costly and an overload for the ED staff capacity. Especially the treat-and-release ED visits are marked as being partly and potentially avoided; it is remarkable that 32.2% of all ED visits take place with patients seen in fewer than 15 min [22]. It is estimated that about 20–40% of all ED visits are generated by patients with non-emergent concerns [6].

Identifying appropriate and inappropriate ED use is key to understand the emergency need of an ED visit and its potential preventability. The New York University Emergency Department severity algorithm attempts to classify ED visits on its level of clinical emergency [4, 5, 23]. The algorithm has been adapted for use by the Centers for Disease Control and Prevention to describe the characteristics of high safety-net burden EDs. The algorithm was developed with the advice of a panel of ED and primary care physicians. It is based on an examination of a sample of almost 6000 full ED records. Data abstracted from these records included the initial complaint, presenting symptoms, vital signs, medical history, age, gender,

diagnoses, procedures performed, and resources used in the ED. Based on this information, each case can be classified into one of the following categories:

- *Non-emergent*. The patient's initial complaint, presenting symptoms, vital signs, medical history, and age indicate that immediate medical care was not required within 12 h;
- *Emergent/primary care treatable*. Based on information in the record, treatment was required within 12 h, but care could have been provided effectively and safely in a primary care setting. The complaint did not require continuous observation, and no procedures were performed or resources used that are not available in a primary care setting (e.g., CAT scan or certain lab tests);
- *Emergent—ED care needed—preventable/avoidable*. Emergency department care was required based on the complaint or procedures performed/resources used, but the emergent nature of the condition was potentially preventable/avoidable if timely and effective ambulatory care had been received during the episode of illness (e.g., the flare-ups of asthma, diabetes, congestive heart failure);
- *Emergent—ED care needed—not preventable/avoidable*. Emergency department care was required and ambulatory care treatment could not have prevented the condition (e.g., trauma, appendicitis, myocardial infarction).
- *Unclassified*. Cases involving a primary diagnosis of injury, mental health problems, and alcohol or substance abuse are separated out.

Treat-and-release ED visits are identified using claims data as presented for KPI 4 on ED visits in Sect. 2.3.4. Based on the primary diagnosis, each ED visit is assigned a set of probabilities into three categories from the list above classified as (potentially) avoidable: non-emergent, emergent/primary care treatable, and emergent—ED care needed—preventable/avoidable.

2.3.7 KPI 7: Avoidable Admissions

There is a long-standing tradition to reduce the number of unplanned admissions. It is believed that early interventions or outpatient care for particular medical conditions can decrease the demand in admissions. Ambulatory care sensitive conditions (ACSCs) are conditions for which appropriate outpatient care can take away the need for an admission, or an early intervention can prevent complication or deterioration. We use prevention quality indicators (PQIs), which were developed by AHRQ, to identify such ACSCs in hospital discharge data and ED visits [28]. High rates of hospitalization for these ACSCs in a defined population of beneficiaries could indicate that the beneficiaries are not receiving high-quality outpatient or ambulatory care. Therefore, measuring these outcomes can provide clear, actionable information on how healthcare systems could improve the care they provide to their beneficiaries.

PQIs are typically measured as admission rates for chronic and acute conditions such as diabetes, chronic obstructive pulmonary disease (COPD) or asthma, hyper-

tension, heart failure, bacterial pneumonia, or dehydration. PQI admission rates are subject to certain exclusion criteria, such as a minimum age of 18 years and exempt transfers, for example, from another hospital.

2.3.8 KPI 8: Leakage

Leakage is the process of beneficiaries seeking out-of-network care or being referred out-of-network by in-network healthcare providers. This means that patients will receive care outside of the network of providers that their health insurance or plan has arranged for. In some cases this cannot be avoided, for example, when a specific type of specialist is not part of the network. However, in many cases, leakage could have been avoided and rather occurs due to reasons such as the patient's preference or because an in-network provider actually refers a patient to a provider outside the network, for example, due to their reputation or due to the patient's choice.

Leakage is a huge barrier to ACOs to accomplish the triple aim in improving care for the individual, improving population health, and reducing per capita costs. This is because once beneficiaries leave the ACO network, they are effectively obtaining unmanaged care. Health providers outside the network do not necessarily adhere to the same quality or cost standards, and it furthermore becomes a huge challenge to coordinate care among the ACO and the out-of-network providers. Additionally, the ACO loses out on the revenue that offering those medical services would have provided, while on the other hand the fees for out-of-network services may be much higher than those inside the network, hence increasing the total cost of care figures.

We define the *annualized* or *total leakage rate* as the total cost spent out-of-network by the attributed beneficiary patient population divided by the total cost of the attributed beneficiary patient population. Next to leakage, we define *retention* as the complementary of leakage: the total cost minus the spending due to leakage. Retention hence refers to all in-network services provided to the attributed beneficiary patient population.

2.3.9 KPI Dashboard

Figure 1 shows an example of a KPI C-level dashboard where all the KPIs described above are computed for a fictitious ACO and graphically presented in a single dashboard. The latter would allow a financial manager to have a quick and compact overview on the financial status of his or her organization.

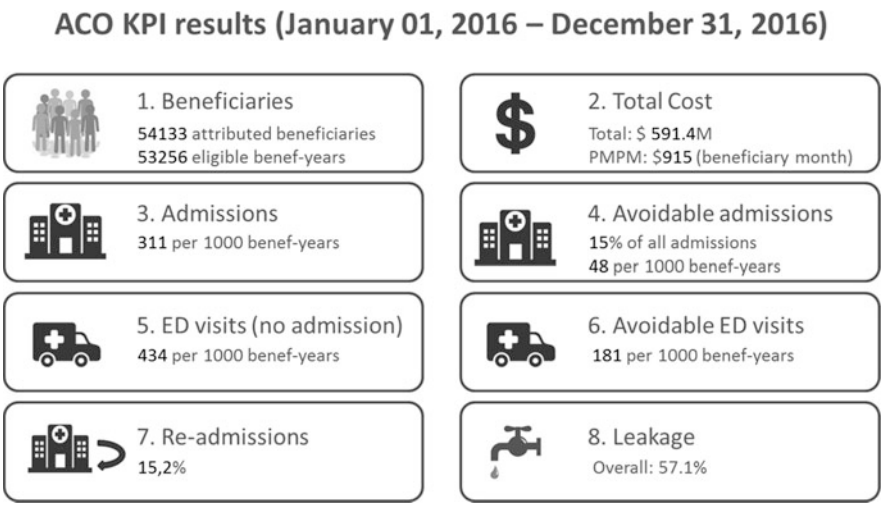

Fig. 1 Example of a KPI C-level dashboard reporting all the described KPIs and corresponding values for a fictitious ACO

2.4 Methods to Drill Down into the Results of the Financial Performance Assessment

The KPIs described in Sect. 2.3 are fundamental to keep an eye on the financial performance of a healthcare organization involved in a value-based contract. However, in order to better understand these KPIs and come to actionable information for these organizations to improve the care they provide to their beneficiaries, one needs to be able to dive deeper. Therefore, we have identified a number of drill downs that allow moving from summary information towards more actionable information by focusing on specific attributes. The following list shows a number of drill-down categories and examples:

- *Patient demographics*: patient demographics such as age, gender, ethnicity, and postal code form a basic way to categorize our statistics.
- *Clinical conditions*: manageable, clinically meaningful categories offer a great tool to investigate the results while focusing on the conditions of patients. Examples of categorizations used include the Clinical Classifications Software (CCS) developed by the Agency for Healthcare Research and Quality [15], Diagnosis Related Group categories, and Major Diagnostic Categories (MDC) [12]. For example, the MDC allows classifying hospitalizations based on the principal diagnosis into 27 categories compared to thousands of ICD-10 codes.
- *Points of care*: this type of classification offers insights into the different settings in which healthcare services are provided. On the highest level, we make a distinction based on the claim type code (CLM_TYPE_CD), which allows us to classify each claim as either being a home health, skilled nursing facility,

outpatient, hospice, inpatient, professional, or durable medical equipment claim. These categories can then again be more refined by the exact type of facility (e.g., rural health clinic or federally qualified health center) which again can be refined by looking at the level of departments within a hospital.

- *Services*: a classification for the services/procedures provided can be used to investigate the procedure utilization and identify the most utilized or costly procedures during hospitalizations. An example of such a classification is the CCS for procedures which allows grouping the procedures into clinically meaningful procedure categories.
- *Risk scores*: a risk model assigns a risk score for each patient at a particular point in time which is then used to categorize patients into a number of risk levels. An example of such a risk model is the CMS-HCC Classification System [26]. This system is used to adjust Medicare capitation payments to Medicare Advantage healthcare plans for the health expenditure risk of their enrollees. Its intended use is to pay plans appropriately for their expected relative costs. The risk levels created by such models represent a group of similar patients which can be a good starting point for another deep dive. For example, one can apply any of the other drill downs to zoom into the high-risk patient level.

As can be seen from the examples, the use case of the different drill downs is providing more clarity into the organization's financial performance. It supports the process of determining the main performance drivers of an organization. As an example, Fig. 2 shows that the inpatient costs are the largest contributor to the

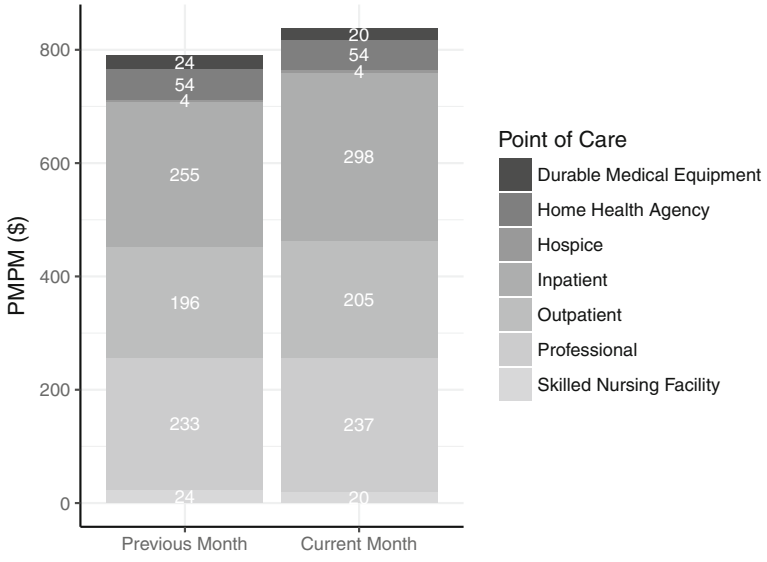

Fig. 2 Example of PMPM for attributed beneficiaries for two consecutive months. The stacked bars show the contribution of each point of care category to the monthly PMPM

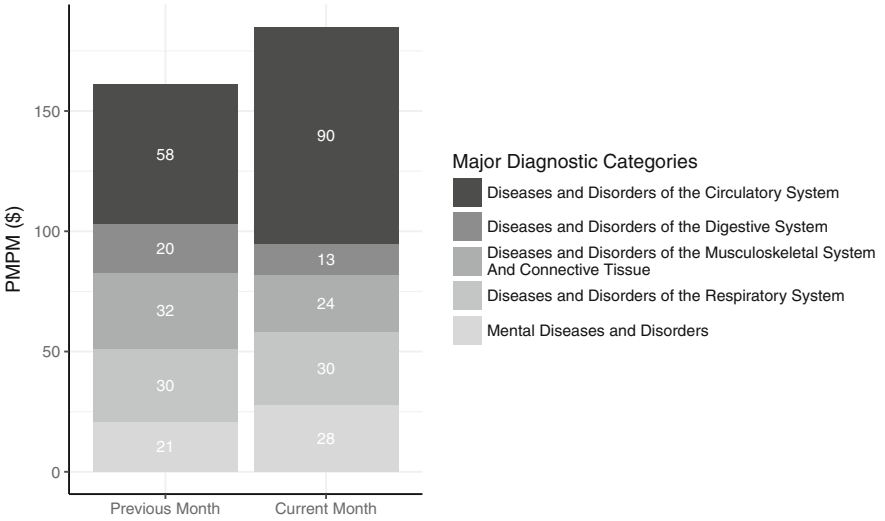

Fig. 3 Drill down with top 5 high-cost MDCs for the admissions of attributed beneficiaries for two consecutive months

total cost of care of the attributed population and increased by almost one quarter compared to last month. However, in order to find pointers towards potential actions that can reduce these costs, one needs to have a deeper understanding of these expenses. Using the Major Diagnostic Categories drill down for the hospitalizations, which is illustrated in Fig. 3, we can now see that the costs related to the MDC "Diseases and Disorders of the Circulatory System" is a large contributor to this increase. This MDC includes conditions such as myocardial infarction, heart failure, coronary artery disease, angina, deep vein thrombosis, cardiac arrhythmia, and hypertension. As a result, one could now zoom into these conditions, investigate whether there are any clear signs of waste, benchmark the results against other organizations, and find new more effective interventions.

3 Conclusions

In this chapter we have provided a basic framework for measuring outcomes and costs in a value-based payment environment. As part of the transition towards value-based care, healthcare organizations are held more and more financially accountable for the outcomes of their patient population. As a result, understanding financial performance, identifying opportunities for improvement, and assessing the efficacy of implemented programs in real time will be key focus for any healthcare provider organization that grows along the path of value-based care. For financial reporting with respect to value-based contracts in healthcare, the following KPIs were found

to be fundamental: beneficiary count, total and PMPM cost, admissions, avoidable admissions, ED visits, avoidable ED visits, readmissions, and leakage. These KPIs offer insights in the organization's financial performance and gives direction with respect to actions for further improvements.

In order for any financial reporting to be transferable and trustworthy, it must be based on widely adopted standards. In order to address this, we have, if available, used CMS-endorsed definitions for the KPIs. These CMS definitions are well documented and, in general, well accepted and used in the healthcare domain. These standardized definitions allow for valid comparison of the KPIs over time and across ACOs.

As it can be seen from the descriptions in this chapter, the computation of the financial KPIs requires different data sources and linkage with external data and information sources. Furthermore, software management and maintenance of coding schemes and data formats used in healthcare reimbursement are prerequisites as they are updated and adapted over time, while financial performance calculation depends on these coding and formats. Especially when processing claims data originating from different entities (e.g., CMS versus commercial payers), one cannot assume the same data formats and conventions, and hence the underlying data model needs to be able to handle these differences. Finally, the medical claims data need to be pre-processed and cleansed to ensure data quality and result validity.

Next to the standard skillset data scientists working in the field of healthcare organizations need to have specific domain knowledge and in this chapter we have shown how a KPI dashboard for financial reporting can be composed to evaluate cost and utilization patterns from claims data.

References

1. Accountable Care Organization - Operational System (ACO-OS) Claim and Claim Line Feed (CCLF) - Information Packet (IP), Version 18.0, Centers of Medicare and Medicaid Services Document Number: NGC.ICDA.0301.18.0.0117
2. ACO #8 - Risk Standardized All Condition Readmissions - Measure Information Form (MIF), Version 2.1, effective 1/1/16. Centers of Medicare and Medicaid Services. https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/sharedsavingsprogram/Downloads/Measure-ACO-8-Readmission.pdf. Accessed Dec 27
3. Barnett, J., Vornovitsky, M.: Health Insurance Coverage in the United States: 2016. U.S. Government Printing Office, Washington (2017)
4. Billings, J., Parikh, N., Mijanovish, T.: Emergency department use in New York City: a substitute for primary care? Commonwealth Fund **433**, 1–5 (2000)
5. Billings, J., Parikh, N., Mijanovish, T.: Emergency department use: the New York story. Commonwealth Fund **434**, 1–12 (2000)
6. Buechner, J.S., Williams, K.A.: Classification of emergency department visits: how many are necessary? Med. Health R I Mar. **90**(3), 96–97 (2007)
7. Centers for Medicare and Medicaid Services Fact Sheet Two-step attribution of measures included in the value modifier (2015). https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/PhysicianFeedbackProgram/Downloads/Attribution-Fact-Sheet.pdf. Accessed 19 Dec 2017

8. Centers of Medicare and Medicaid Services Defining the Medicare Severity Diagnosis Related Groups (MS-DRGs), Version 34.0. https://www.cms.gov/ICD10Manual/version34-fullcode-cms/fullcode_cms/Defining_the_Medicare_Severity_Diagnosis_Related_Groups_(MS-DRGs)_PBL-038.pdf. Accessed 11 Jan 2018
9. Centers of Medicare and Medicaid Services Fact Sheet New Accountable Care Organization Model Opportunity: Medicare ACO Track 1+ Model. https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/sharedsavingsprogram/Downloads/New-Accountable-Care-Organization-Model-Opportunity-Fact-Sheet.pdf, Accessed 11 Jan 2018
10. Centers of Medicare and Medicaid Services Readmissions Reduction Program. https://www.cms.gov/medicare/medicare-fee-for-service-payment/acuteinpatientpps/readmissions-reduction-program.html
11. Centers of Medicare and Medicaid Services Shared Savings website, https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/sharedsavingsprogram
12. DRG Expert 2018 (2017), Optum 360
13. Goodell, S., DeLia, D., Cantor, J.C.: Robert Wood Johnson Foundation Policy Brief No. 17: Emergency Department Utilization and Capacity Robert Wood Johnson Foundation, Princeton (2009)
14. Healthcare Cost and Utilization Project. https://www.hcup-us.ahrq.gov
15. Healthcare Cost and Utilization Project Clinical Classifications Software (CCS). https://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp
16. Healthcare Cost and Utilization Project Tools and Software. https://www.hcup-us.ahrq.gov/tools_software.jsp
17. Iezzoni, L.I.: Risk Adjustment for Measuring Health Care Outcomes, 3rd edn. Health Administration Press, Chicago (2003)
18. Medicare Shared Savings Program - Uses and Limitations of the Claim and Claim Line Feed - User Guide, Centers of Medicare and Medicaid Services, Version 3, February 2017
19. Mendelson, A., Kondo, K., Damberg, C., Low, A., Motúapuaka, M., Freeman M., O'Neil, M., Relevo, R., Kansagara, D.: The effects of pay-for-performance programs on health, health care use and processes of care: a systematic review. Ann. Intern. Med. **166**(5), 341–353 (2017)
20. Mitchell, E.: Statistical Brief #497: Concentration of Health Expenditures in the U.S. Noninstitutionalized Population, 2014. Agency for Healthcare Research and Quality, Rockville (2016)
21. Moore, B., Levit, K., Elixhauser, A.: HCUP Statistical Brief 181: Costs for Hospital Stays in the United States, 2012. Agency for Healthcare Research and Quality, Rockville (2014)
22. National Hospital Ambulatory Medical Care Survey: 2014 Emergency Department Summary Tables (2014). https://www.cdc.gov/nchs/data/nhamcs/web_tables/2014_ed_web_tables.pdf. Accessed 27 Dec 2017
23. NYU Center for Health and Public Service Research ED utilization classification. https://wagner.nyu.edu/faculty/billings/nyued-background
24. OECD Health Statistics: WHO Global Health Expenditure Database (2017). Accessed 11 June 2018
25. Papanicolas, I., Woslie, L.R., Jha, A.K.: Health care spending in the United States and other high-income countries. JAMA **318**(10), 1024–1039 (2018)
26. Pope, G., Kautter, J., Ellis, R., Ash, A.S., Ayanian, J.Z., Iezzoni, L.I., Ingber, M.J., Levy, J.M., Robst, J.: Risk adjustment of medicare capitation payments using the CMS-HCC model. Health Care Financ. Rev. **25**(4), 119–141 (2004)
27. Porter, M., Olmsted Teisberg, E.: Redefining Health Care: Creating Value-Based Competition on Results. Harvard Business Review Press, Boston (2006)
28. Prevention Quality Indicators. Agency for Healthcare Research and Quality. https://www.qualityindicators.ahrq.gov/modules/pqi_resources.aspx
29. Research Data Assistance Center (ResDAC). https://www.resdac.org
30. Tang, N., Stein, J., Hsia, R.Y., Maselli, J.H., Gonzales, R.: Trends and characteristics of US emergency department visits, 1997–2007. J. Am. Med. Assoc. **304**(6), 664–670 (2010)
31. Tsuguwa, Y., Jha, A.K., Newhouse, J.P., Zaslavsky, A.M., Jena, A.B.: Variation in physician spending and association with patient outcomes. JAMA Int. Med. **177**(5), 675–682 (2017)

32. Venkatesh, A.K., Mei, H., Kocher, K.E., Granovsky, M., Obermeyer, Z., Spatz, E.S., Rothenberg, C., Krumholz, H.M., Lin, Z.: Identification of emergency department visits in medicare administrative claims: approaches and implications. Acad. Emerg. Med. **24**(4), 422–431 (2017)
33. Weiss, A.J., Wier, L.M., Stocks, C., Blanchard, J.: HCUP Statistical Brief 174: Overview of Emergency Department Visits in the United States, 2011. Agency for Healthcare Research and Quality, Rockville (2014)
34. Wennberg, J., Gittelsohn, A.: Small area variations in health care delivery. Science **182**(117), 1102–1108 (1973)
35. World Health Organization List of Official ICD-10 Updates. http://www.who.int/classifications/icd/icd10updates/en/