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Bundled payment contracts in Dutch cardiology centers

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Summary

Introduction

Health care costs in the Netherlands have risen substantially for the last decades. In 2015 almost 30 percent of the €95.3 billion was spent on hospital and specialist care. The Netherlands, just as many other countries, have been looking to reduce these costs while still improving quality of care. History has shown that traditional forms of payments have not been unable to contribute to this goal. New forms of payments, including pay-for-performance (P4P) and bundled payments, are therefore being introduced. To the best of the author's knowledge, bundled payment programs to finance hospital care in the Netherlands have not yet been implemented.

Objective and research question

This report will attempt to design a bundled payment model for percutaneous coronary intervention (PCI) for Dutch cardiac care providers. PCI is the standard treatment for acute myocardial infarction and other coronary artery diseases. PCI was chosen for this report since it is a treatment with a clear beginning and since it is, to a large extent, a standardized treatment. Furthermore, there are multiple experiences with the reimbursement of PCIs through bundled payments. The goal of this report can be summarized in the following research question: *How to design a new bundled payment product for percutaneous coronary intervention (PCI) in Dutch secondary care that creates incentives to reduce costs and to improve the quality of care?*

Theoretical framework

A bundled payment is a payment form in which providers receive a fixed amount of payment per patient having a certain illness or per treatment episode. The overall goal of bundled payments is to incentivize providers to improve quality, reduce costs and reduce the number of unnecessary services within a certain treatment episode. Incentives for adverse patient selection and underuse are present for which case-mix correction and use of quality metrics are imperative. A bundled payment should therefore consist of a case-mix corrected tariff for services and a separate bonus tariff for quality.

Methods

A literature search for previous experiences on bundled payments for PCI, expert opinion from the organization MeetbaarBeter® and claims data from the health insurer Menzis® were used to design the model. The model was designed in five phases, defining: the patient (1), the time-frame (2), the content (3), the case-mix corrected bundle tariff (4) and the bonus tariff (5). Claims data were used of patients, insured by Menzis, who underwent a PCI between January 1 and June 30 2015. Seven case-mix variables were derived from the claims data (e.g. age, diabetes and PCI category). A multiple linear

regression was performed to calculate the bundle tariff and a binary logistic regression was done to calculate case-mix corrected performance on five quality metrics (e.g. mortality, extra PCI).

Results

Literature search: Six bundled payment programs including PCI were found, all are US programs. Most programs have a time-frame of 30 or 90 days after initial treatment. Explicit difference between acute and elective PCI's was made in the content of the programs and only care directly linked to the PCI was included in the bundles. Each program has exclusion criteria such as age, outliers in costs or predefined diagnoses but only two performed risk-adjustment to their programs. Quality metrics were registered in each program and most of the programs added some form of pay-for-performance to their bundled payment. Evaluations of many of these programs have not been published.

Design of the model: A total of 2135 patients, from 31 different Dutch hospitals, were used from the Menzis claims dataset for the analysis. Average claimed tariff of diagnosis-related-groups (DRGs) in a 6-month period was €10,590.19 (±6,779.66), 27.92% was female and the average age was 64.74 (±11.40) years. There was a difference in claimed tariff between an acute and elective PCI: €12,507.68 (±6,510.11) vs. €8,868.70 (±6,553.64) respectively. The patient was defined as any patient, older than 18, who receives a PCI or attempted PCI, in any setting and in any type of artery. The time-frame was set on six months (i.e. 183 days) for emphasis on long term care and prevention. All cardiac care performed within this 6-month period was included due to the difficulty of determining care that is (un)related to the initial PCI. Excessively expensive care was excluded using a stop-loss agreement. The stop-loss agreement threshold for this model was set on 120% of the mean of the total claimed tariff (€10,590.19*120% = €12,708.23). For the calculation of the patient specific bundle tariff, 452 of the 2135 patients were excluded due to this threshold. The linear regression, for calculating the bundle tariff, has a R^2 of 0.4019, a F-value of 93.51 (p<.001) and a constant of €7325.19. The bundle tariff for quality, which is hospital specific, was calculated by comparing the predictive value to the actual outcome. A maximum bonus or penalty of 5% of the bundle tariff was used for quality. Division by five variables resulted in a maximum bonus or penalty of 1% of the total bundle tariff per outcome variable. This maximum is reached when a relative difference of 50% (or minus 50%) between prediction and actual outcome is achieved.

Discussion

Each phase of the bundle design requires many choices and/or agreements which depend on the preferences of providers and payers. It is for this reason that a multi-disciplinary team is needed that must agree upon every phase in order to create a well-designed bundled payment model. The patient can, for example, be defined differently according to diagnosis or setting of the PCI (acute or elective). The time-frame is arbitrary and could also include the period before an elective PCI (i.e. the diagnostic

work-up). The content could specifically define treatments that need to be excluded from the bundle since they are evidently unrelated to the initial PCI. The stop-loss agreement of 120% was chosen for minimizing the risks for providers when implementing the program but it could also be increased. To calculate the tariff, by using a linear regression, more or different case-mix variables could be chosen. This is equally the case for the quality element of the bundle and the independent variables which are used to calculate the predictive values of outcome. Finally, the percentage for pay-for-performance is subjective and needs to be agreed upon by the providers and the payers. Agreement also needs to be reached for the maximum bonus and penalty.

The limitations of this report include the limited availability of evidence in literature and data for the analysis of the tariff.

Conclusion

By using the concept of bundled payments and the experiences of previous programs this report has designed a bundled payment which can be used by providers and payers to make contractual agreements on health care payments. It can best be used as a template for designing and further optimizing bundled payment programs. The model in this report was specifically designed for percutaneous coronary intervention (PCI), but the phases of the model are applicable to other types of treatments and diagnoses. More research is not necessarily needed on the concept of bundled payment but more research is needed on the details of the implementation.

Acknowledgements

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Introduction

Background

How can the growth of health care costs be stopped while still improving the quality of care? This question has been important for decades since health care costs have risen in every western society, and still do.[1] In the Netherlands, for example, the costs have risen from 10 percent of the GDP[i] in 2000 to 14 percent (a total of €95.3 billion) in 2015.[2] An important part of these costs is specialist care. Almost 30 percent (€26.4 billion) of the total health care spending is comprised of costs in hospital and specialist care.[3]

From 1946 until approximately 1970, after the introduction of the National Health Fund, the only form of hospital payment in the Netherlands was fee-for-service (FFS).[4] FFS is a payment form in which hospitals (e.g. physicians) receive a payment retrospectively for each service they provide, such as a treatment or consultation. FFS is still a frequently used form of payment worldwide.[5] It does not, however, give providers incentives to save costs or to limit spending.[6] In order to limit spending in health care, global budgets were more gradually introduced during the 1980's.[4] This advance lump-sum payment covers all the services a provider gives, regardless of the exact amount of patients.[5] This, on the other hand, caused waiting lists when providers exhausted their budget. This had as a consequence that they would only be able to treat patients after an extension of the budget was agreed.[4,7] Furthermore, budgeting can cause underuse[ii] of care, which by definition does not contribute to the quality of care.[13] From 2005 on, the payment of hospitals in the Netherlands is done by diagnosis-related-groups (DRGs). DRGs are prospective payments for a specific period of time per patient and for a specific diagnosis.[5] All services related to the diagnosis are included in the group. Providers are then incentivized to provide fewer services linked to the diagnosis and, therefore, they might have less costs. However, because payment is still done per patient and not globally, providers are still being incentivized to increase their number of patients.[5,8] Although in this case underuse is being prevented, overuse[iii] is more likely to appear in DRGs, similar to FFS.

Traditional forms of payment

The behavior of providers is influenced by many factors including education and ethics, but also by their organizations and by their financing.[9] The incentives of the most frequently applied forms of payment to hospitals and secondary care providers as well as the new bundled payment form are discussed below.

[i] Gross Domestic Product (GDP)

[ii] Underuse is defined as the failure to use effective and affordable medical interventions[13]

[iii] Overuse is defined as the provision of medical services that are more likely to cause harm than good[11]

Fee-for-service (FFS)

FFS is capable of creating provider induced demand.[10] Physicians (or hospitals) receive a fixed amount of payment for every treatment or action they perform and so they are more likely to induce demand or increase the services they provide without necessarily improving quality.[9,10] It is, therefore, likely that overuse of medical services in a market-driven health care system is linked to FFS (and, discussed below, DRGs).[11] Furthermore, physicians have no incentive to withhold medical care due to financial reasons. For quality, FFS creates incentives for high patient satisfaction. Patients are more likely to return to the provider when previous care was adequate and they need more services.[6] Another negative aspect of FFS is that there is no incentive for technical quality improvement, because extra payments will be done when patients return for additional treatment or complications. As an example: in a study comparing FFS with global budgeting, Lurie et al (1994) found that the likelihood of patients in the latter group to have a physician visit was 16.5% less than for patients in the FFS group.[12]

Global Budgeting

As stated above, global budgeting may be linked to underuse. However, in contrast to FFS, it does incentivize providers to save costs. Providers may be inclined to provide less care when paid one fixed amount.[13,14] In global budgeting there is no direct incentive for more quality of care, especially concerning patient satisfaction. Additionally, a global budget can lead to access problems and an increase in waiting times when sufficient funds are not available.[5] On the positive side, a global budget may incentivize providers to be more active on preventive care, since providers would want to prevent patients to return for additional care.[6] When done effectively, this can improve the quality of the care provided (e.g. when readmissions are prevented).

Diagnosis-related-groups (DRGs)

The final traditional form of payment is DRGs. In most cases a DRG applies to a single provider for a single diagnosis. DRGs can therefore create an incentive for reducing the length of stay or the amount of additional diagnostic tests since a fixed amount is paid for a single diagnosis.[5] The early discharging of patients, linked to the initial diagnosis, can therefore save costs and improve quality.[6] However, a DRG, in the Netherlands, is a collection of services provided and not solely based on the diagnosis; there are multiple DRGs for one diagnosis, depending on the services. For example, a DRG for a certain diagnosis with a maximum of 6 hospital days is less expensive than a DRG that, for the same diagnosis, includes 6 till 28 hospital days.[28] This can create incentives to provide more care so that a DRG can be 'scaled-up' (or up-coded). A good illustration of this was the implementation of DRGs in the *Prospective Payment System* in the 1980's in the US. Medicare expected a maximum 3 percent increase of costs through higher coding while the actual index turned to be around 9 percent. This caused Medicare to pay hospitals close to $2.4 billion per year extra.[15] Furthermore, new DRGs can be 'opened' (or

initiated) when complications occur or when the time-frame of an old DRG has passed. The incentive for quality improvement or preventive care may therefore vary by DRG and the services that are part of the DRG.[6] As a result, DRGs cause inadequate incentives for actual improvement of quality or cost-efficiency.[16]

The need for bundled payments

When analyzing the traditional forms of payments it can be concluded that, despite their frequency in everyday practice, they cannot be considered to be effective in reducing costs without negative effects on quality.[5,17] Since health care costs are still rising, it is important to look for alternative forms of payments[5] and it is for this reason that many governments of western countries (and third party payers) are attempting to revolutionize the financing of hospitals.[17] In search for an alternative form of payment, they attempt to incentivize providers to save costs while simultaneously improving the quality of care.

Several countries have already implemented alternatives. The National Health Service (NHS) in the United Kingdom, for example, implemented the *Quality and Outcomes Framework* in 2004.[18] Although primarily intended for primary care providers, this allowed payments to be based on quality using pay-for-performance (P4P). Or Medicaid/Medicare in the United States (US) which introduced, through the Affordable Care Act (ACA), the model of accountable care organizations (ACOs). ACOs are groups of doctors, hospitals and other providers that receive a fixed amount of prospective payment based on their size and their population; a form of capitation.[19] The goal of the ACA is to create financial incentives for ACOs to lower growth in health care costs while performance standards on quality of care are being met. [20]

Another example is the implementation of bundled payment models. Hospitals receive a single payment for all the services they provide during a clinical episode.[19] Bundled payments were first implemented in the US in 1984[21] and are being implemented more widely since the ACA was enacted.[19] For example, as of July 2017, bundled payments for acute myocardial infarction (AMI) will be introduced through Medicaid/Medicare. Its objective is to make providers financially accountable for the quality and costs of an entire AMI episode and to incentivize providers to coordinate care among other providers, physicians and post-acute care.[22]

To the best of this author's knowledge, bundled payments for hospital care have not yet been implemented in the Netherlands, despite the consistent, but unfortunately weak, evidence on cost reduction and quality improvement.[24] This report aims to investigate how bundled payments can be implemented in the Dutch health care system as a new form of hospital payment, specifically for cardiology.

Objective and research questions

This report will attempt to design a bundled payment model for cardiac care provided by Dutch secondary health care providers (including hospitals). The cardiac care within this model will be limited to percutaneous coronary intervention (PCI), the standard treatment for acute myocardial infarction (AMI) and other coronary artery diseases. This treatment is chosen for the experience with its reimbursement through bundled payments.[21,24] Furthermore, PCI is to a large extent standardized. It is a procedure with a clear beginning and ending, making bundled payment models feasible.[23]
It is expected that the new model will be implemented through a new purchasing contract (product) between a Dutch health care insurer and health care providers. To create this model, available insurance claims data from health care insurance company Menzis Zorgverzekeraar N.V.® (Menzis) will be used to define the bundle and to calculate the costs of the bundle.

The goal of this report can be summarized in the following research question:

How to design a new bundled payment product for percutaneous coronary intervention (PCI) in Dutch secondary care that creates incentives to reduce costs and to improve the quality of care?

This overarching goal is broken down into the following sub-questions:

- What is already known in literature about bundled payments for PCI?
- How could the bundle be defined, e.g. which type of patient, treatments (incl. readmissions, post-discharge care) and other provisions of care should be included in the bundle? What time-frame should be used for this model?
- How can risk-adjustment be implemented in this model?
- What would be an appropriate price (range) of the bundle?
- How can the use of quality metrics be added to the bundle?

These sub-questions are derived from a report of the American Hospital Association, discussing key issues for consideration when implementing bundled payment models.[25]

Theoretical framework

A literature search on bundled payments was done to create a theoretical framework of bundled payments. This framework could then be used for the actual designing of the bundle. GoogleScholar was used for the literature search on bundled payments using the following search term: *'bundled payments' OR 'episode payments' OR 'pooled budgets' OR 'pooled funds' OR 'integrated payments' OR 'integrated funds'* (all in title)

No exclusions were made on year of publication. This gave a total of 256 hits. The title and abstract (consecutively) were then screened for content on the general principle, incentives and challenges of bundled payments. This resulted in 24 articles, for two of these no full text was available. Additionally, three articles were found when reading the full text articles. Articles were then categorized in general principle, incentives and challenges and used for the theoretical framework.

General principle of bundled payments

Hussey et al (2012) defines the term bundled payment, or episode-based payment, as: *a method in which payments to health care providers are related to the predetermined expected costs of a grouping, or "bundle," of related health care services.*[24] In other words, providers receive a fixed amount of payment per patient having a certain illness or per treatment episode.[25] This payment includes the treatment itself and complications associated with the treatment. The overall goal of bundled payments is to incentivize providers to improve quality, reduce costs and reduce the number of unnecessary services within the bundle (e.g. reducing avoidable complications, reducing post-discharge costs and prevent overuse).[24,26,27] By spending less than the prospectively determined amount of the bundled payment, providers save money and are able to increase their return. It is for this reason that bundled payments do have similarities with DRGs and capitation[iv]. However, a DRG-system commonly does not include post-discharge costs, has a limited time horizon (mostly equal to the clinical episode, e.g. maximum of 42-days in the Netherlands) and does not offer the opportunity to include out-of-hospital care. Furthermore, it puts the third party payer (insurer) at financial risk, since they cannot predict precisely how many DRGs will be claimed.[25,28] This is also an uncertainty for the hospital management. While capitation does include post-discharge costs and usually has a broader time-frame, it also gives the provider full financial risk.[25] By using bundled payments, both the provider and the insurer share this risk. The provider has a financial risk in potentially having to treat patients which require more services than the bundle contains while the insurer still bears the risk of not knowing how many patients will need the bundle of services.[25,27] The first risk can be mitigated by appropriate case-mix adjustment when calculating the price of the bundle, whereas the latter risk can be mitigated by contracting a maximum amount of bundles.

[iv] capitation is a fixed amount per capita per year

Incentives

As with any payment system, several incentives influence the conduct of providers in everyday practice. These incentives can have different effects. They, for example, can lead to saving costs in unnecessary physician services but they can also cause a reduction in the quality of care. Below, the main incentives linked to bundled payments are discussed including their possible effect and, if necessary, a solution to adjust these effects is suggested. It is, however, important to mention that the effects can be positive or negative depending on the point of view of different stakeholders (i.e. patients, insurers and providers). For instance, cost saving cannot be defined as positive per se, since it can also be caused by a reduction of necessary care. The incentives mentioned are only applicable to physicians whose services are linked to the payment of these services, either directly (payment per service/bundle) or indirectly (through employment in hospital). The incentives are summarized in Table 1.

Table 1. Overview provider incentives within bundled payments

Incentive	Effect
Saving costs	Working across specialties Improving efficiencies Reducing complications Reducing unnecessary care
Underuse	'Racing to the bottom' Reducing necessary care Providing necessary care after time-frame of bundle
Adverse selection	'Cherry picking'
Overuse and increasing costs	Increasing volume of – (un)necessary – bundles Increasing services outside the bundle
Quality of care	Improving quality indirectly through the incentive saving costs Improving quality directly through quality indicators 'Gaming' on quality results

Incentives to save costs

Cutler and Ghosh (2012) suggest in their study that it is possible to achieve very substantial health care savings by switching from a FFS to a bundled payments system.[29] This is because a fixed amount per episode is paid and so providers will most likely save costs on services within the bundle. There are several possibilities for providers to save costs without reducing necessary care, for example:

- by substituting care of high-cost providers by less costly providers; for example when a bundle includes relatively inexpensive services by a general practitioner (GP) or physical therapist, a specialist can refer patients to them, instead of treating the patients themselves. [30,31]
- by improving operational efficiencies or changing patient/practice protocols and reducing unnecessary care; for example, reductions in the frequencies of superfluous laboratory or other diagnostic tests.[27,30]

- by reducing avoidable complications and readmissions.[31]

Incentive for underuse

Not only reducing unnecessary care can save costs, but also reducing necessary care, i.e. underuse[v], can reduce spending.[27] Underuse can occur when providers are faced with maximum budgets (e.g. a certain bundle for a specific patient)[13] and especially when providers experience a decrease of that budget over time. For example, it is likely that the agreed price of a bundle will gradually drop in years to follow as providers are able to improve their efficiency. As providers notice this drop in financing, they may take unnecessary risks to control their costs further since they are expected to work even more efficiently, especially in a competitive market.[30] Andrawis et al (2016) describe this as a 'race to the bottom'.[30] Reduction of necessary care, per definition a reduction in quality, is important to prevent. A good example is an increase in mortality. Deceased patients, who have died before the end of the bundle time-frame, might be less expensive patients since they might have used fewer services. This can be prevented by using quality metrics and making them a part of the bundle. This necessity does not only apply to underuse, but also to delay any necessary care to the period after the bundle.[27]

Incentive for adverse selection

In line with underuse is the selection of patients since some patients might cost less than others. In other words, some might save funds while others might exceed the amount the bundle provides. This might incentivize providers to take part in 'cherry picking' (i.e. limited access for complex or sicker patients or 'adverse selection').[27,30,32,33] Case-mix correction, or risk-adjustment, is for this reason imperative when wanting to succeed in implementing bundle payments.[27,32] This way, costly patients are still able to receive care because they are represented in the calculation of the weighted price of the bundle. To perform a successful case-mix correction, comorbidities and severity of disease have to be defined and scored.

In addition to case-mix correction, implementing exclusion criteria for patients is also a method to reduce cherry picking. When certain patients are excluded from the bundle and their costs are reimbursed traditionally, these patients will not be a financial risk for providers and the chances of denying them care will reduce. This exclusion can be done either through a stop-loss model (i.e. costs of an individual patient exceeding a predetermined amount) or defining which patients should be excluded completely beforehand (e.g. above a certain age or with a certain disease).[40,41]

Incentive for increasing costs and overuse

When, as mentioned above, insurers bear the risk for the number of patients, providers might also be more incentivized to increase the volume of bundles.[27,33] This can be useful in case of waiting list

[v] Underuse is defined as the failure to use effective and affordable medical interventions[13]

reduction, as was seen in Sweden after the implementation of bundled payments for knee and hip replacement.[34] But also, in a competitive market, when providers with higher quality want to attract patients from other providers.[33] However, an increase in services can also occur if providers want to prevent a cutback in their total earnings.[27,33] In that case they have an incentive to increase the number of bundles or the number of services reimbursed separately, apart from the specific bundle. This in turn can lead to additional necessary care or unnecessary care (i.e. overuse).[vi] Therefore, when designing a bundle, a possible effect of increase in volume of bundles has to be taken into consideration. Especially since the ultimate goal of bundled payments is overall cost reduction.

Incentive for improving quality of care

Quality of care within bundled payments can be distinguished between a reduction of, preventable, complications and a direct increase in quality. The first is described in the '*incentives to save costs*' section, since this also leads to a reduction in costs; the latter can be stimulated by payments directly based on quality indicators. When the amount paid is based on quality, providers are incentivized to actively improve quality.[6] Not only by improving their services in general but also by investing in better or new services, especially in a competitive market. [35] Also, an additional payment on quality is needed to incentivize providers to reduce underuse and overuse so that an increase in revenue is not merely dependent on the amount of services. Bundled payments can therefore only be successful when quality metrics and payment for this quality are part of the bundle (i.e. an element of P4P).[6,25] However, a risk of P4P is that providers focus on improving the quality indicators that are registered and neglect other aspects of quality (not monitored by indicators). A well-known effect of registering quality indicators, which are linked to P4P programs, is the process of 'gaming' (i.e. manipulating data so that performance appears to be increased), for example by excluding certain patients from the calculation of the indicator.[36] This can be addressed by systematically collecting patient-experience data or controlling/registering the data by third parties.

Challenges

As with other payment forms, bundled payments come with challenges and these should be addressed when implementing this form of payment. These challenges are summarized in Table 2.

Effect on patient experience

For a great part it is still unknown what the effects of bundled payments are on patients' experience. This was concluded not only by the RAND organization (2010)[27] but also by Hussey et al. (2012)[24] in their review. Although logic implies that focusing on outcome quality indicators will increase patients' experience, evidence is still needed. This lack of evidence might be explained by the difficulty of

[vi] Overuse is defined as the provision of medical services that are more likely to cause harm than good[11]

isolating the effects of a certain payment form on patient experience, since patient experience is influenced by multiple factors. These include not only outcome, but also facility quality and behavior of personnel.[37]

Table 2. Overview challenges for bundled payments

Challenges	Specified
Effect on patient experience	As of now, bundles have an unknown effect on patient experience
Data collection	Much data is needed for quality, case-mix and costs Often uncertain to focus on which indicators Actual costs of services are often not insightful
Effects for certain providers	Providers who already made investments might be penalized Teaching hospitals or small rural hospitals might bear more financial risks Providers might have a small population with a certain insurance company
Specific conditions	Most suitable for acute care, with clear beginning-ending , clear clinical guidelines and well-defined pathways
Defining complications	Difficulty in defining complications which are linked to the episode
Switching from insurer and/or provider	Difficulties when patients switch either insurance or provider during an episode of care

Data collection

As mentioned earlier, data collection of well-defined quality indicators and case-mix is important for creating and maintaining bundled payments. When done properly, transparency of care can increase.[38] However, data collection is also very difficult and it is one of the reasons why, up to this date, bundled payments are not widely implemented.[31,32] As for quality measurements, it is often the case that there are too many indicators that have to be recorded since it is often uncertain to which indicators quality measurements must be limited. This can lead to insufficient and incomplete data. It should be agreed upon which indicators are important and which are not.[25,31,32,39] As for costs and price, it is key to know what the actual costs are of service provided and ideally the bundle tariff is based on these actual costs.[5,31,32] But in the Netherlands, for example, prices of DRGs are rarely based on actual costs but rather on agreements between the insurer and the provider. Often, first a total budget is agreed. Next, an agreement on the prices of the DRGs is made, which needs to fit within that total budget, instead of a price that is based on actual costs.

Effects for certain providers

In addition to the difficulties in determining the right tariff, it is also possible that already well-organized providers are penalized when a target tariff is set.[30] Providers, who already made investments before the bundled payment will be introduced, are less able to improve their cost-efficiency than providers who had not. Providers already performing well are thus not rewarded, but rather penalized. This can be managed when target price are not provider specific but identical for multiple providers.

Other differences between providers, such as big teaching hospitals or small rural hospitals, should also be taking into account.[15] Teaching (or academic) hospitals might need extra funding for a possible increase in inefficiency because of education obligations, clinical trials or experimenting with innovations. Small rural hospitals might bear more risks for certain episodes since the frequency of these episodes is significantly lower and referring this care to a bigger institution is not possible.[15,40] Even though adequate case-mix correction might be used, there is still a factor of chance for having more patients with higher costs than expected. This risk is higher with a lower frequency of patients. In line with this, private insurers can have a smaller market share in certain hospitals, for example depending on their region. A provider can have a high frequency of episodes of patients insured with one insurer, while having a low frequency from another. In the latter, the provider will bear more risk since this is similar to small hospitals with fewer patients.

Specific conditions

Bundled payments are ideal and preferable for care of an episode with a clear beginning and ending.[23] Also, services which are standardized and well defined in protocols or guidelines lend themselves to bundled care.[31] In many cases this applies only to acute care and less to chronic care, since the latter often entails patients with multi-morbidity needing many different forms of services. Bundled payments can, therefore, be challenging for chronic care. However, there are also advantages for applying it to chronic conditions since they are, for example, big drivers of costs and so the saving potential is higher. In the US, more than two-thirds of Medicare beneficiaries have two or more chronic conditions and so preventing expensive hospitalizations of chronically ill patients (averaging $12,300 plus outliers which are more than 20 times higher) can have a lot of saving potential.[31] Although bundle payments in chronic care can have a lot of saving potential, it is still more difficult to define the bundle than for inpatient surgical and interventional care. Surgical and interventional care not only have a clear starting point, they also often have clear clinical guidelines and well defined pathways, making it easier to determine the bundle and to include/exclude certain services than chronic care.[31]

Defining complications

Although guidelines for certain episodes of care are present, it can be still difficult to determine which complication is part of which treatment; thus, the question is which complication should be included in the episode?[16] Should all services be included in the bundle or only those causally linked to the initial treatment (or start of the bundle)? However, how does one conclude whether a complication is causally linked to the treatment? Often in health care this is very difficult to determine. It is for this reason, that a bundle should be created by a multidisciplinary team, including physicians.[41,42]

Switching from insurer and/or provider

State funded coverage, such as Medicare or the NHS, does not have a high-turnover in its population but private insurance companies might. Bundled payments therefore can be more difficult when, during an episode of care, a patient decides to change insurance.[27] This is also the case when patients decide to switch during an episode from one provider to another, that does not use bundled payments with the patient's insurer. Who is then paid how much when a patient decides to change its provider due to complications or simply changes insurance? This is especially important when, by law, patients are not limited in their choice of providers and they may switch insurance on a yearly basis (i.e. the Netherlands). [43]

Template for a bundled payment model

Taking the incentives and challenges mentioned in this chapter into account, the bundle tariff should consist of two elements (Figure 1).

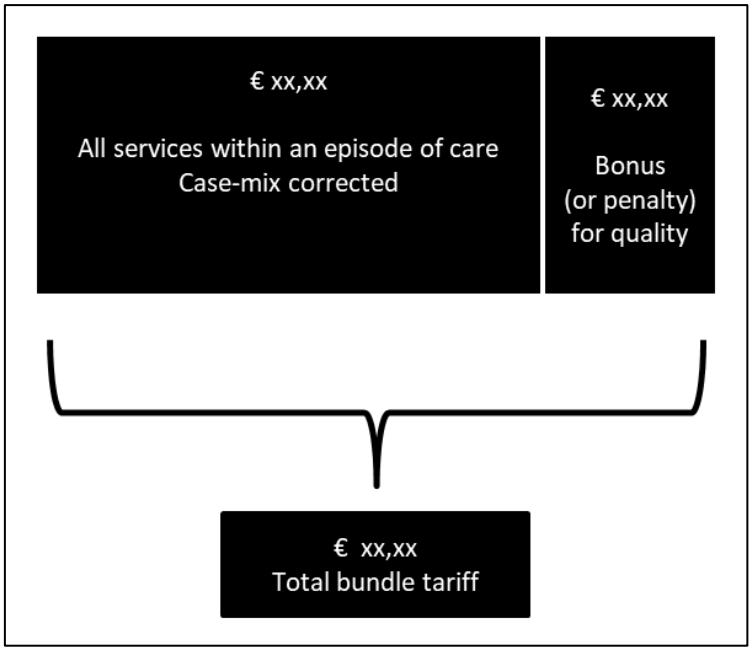

Figure 1. The two components of the bundle, on a patient level.

First, it has to be decided which services are included (e.g. initial treatment and complications) in the bundle and within which time-frame. Then a tariff for these services needs to be determined and this tariff should be case-mix corrected to avoid, among other things, adverse selection. Secondly, a bonus (or penalty) should be added to incentivize providers to improve quality and to limit the chances of underuse or overuse of care.

This report will attempt to build such a model and to create a bundle tariff specifically for percutaneous coronary intervention (PCI).

Methods

To answer the research question and to create a bundled payment model for PCI in Dutch hospitals the following two steps were followed. First, a literature search was done for previous experiences with bundled payments for PCI. Second, claims and administrative data from the health insurance company Menzis and the literature review of previous experiences were used to design the model. This included defining the patient, the content, the time-frame, the case-mix correction and a total tariff for the bundle. These two steps are discussed below in more detail.

Literature search on bundled payments for PCI

For the search on programs of PCI bundled payments, the following search terms were used in GoogleScholar:

"bundled payment" OR "episode payment" OR "pooled budgets" OR "pooled funds" OR "integrated payments" OR "integrated funds" "percutaneous coronary intervention" (anywhere in text)

"bundled payment" OR "episode payment" OR "pooled budgets" OR "pooled funds" OR "integrated payments" OR "integrated funds" "percutaneous coronary revascularization" (anywhere in text)

"bundled payment" OR "episode payment" OR "pooled budgets" OR "pooled funds" OR "integrated payments" OR "integrated funds" "coronary angioplasty" (anywhere in text)

No exclusions were made on year of publication. The three search strategies resulted in a total of 254 hits (173, 5 and 76 respectively). Nine articles were added through the previous search on bundled payments. After removing duplicate hits, the title and abstract (consecutively) were screened for actual programs. This resulted in 41 articles. In addition to the articles found, secondary literature (e.g. websites or reports of these programs) was consulted to assess the following six points of each program: time frame of the bundle, content of the bundle, use of risk-adjustment and exclusion criteria, use of quality metrics, calculation and payment of the tariff criteria and the results (or evaluation) of the program.

Methodology for designing the bundled payment model

The model was created by using the articles found in the literature search and by using retrospective claims data from the Dutch health insurer Menzis. Also, several meetings with the organization Stichting Meetbaar Beter® (MeetbaarBeter) were held.[vii] MeetbaarBeter, including their yearly published handbook[44] and report on quality of cardiac care in the Netherlands[45], was used to

[vii] 'Stichting Meetbaar Beter'®: organization for researching patient-relevant outcome measures. 14 of the 16 Dutch heart centers participate in Meetbaar Beter. Meetbaar Beter has an advisory council which consists of cardiologists from these heart centers.

determine patient profiles, important case-mix variables and outcome variables. In the Netherlands, MeetbaarBeter is generally regarded as the leading quality improvement initiative in cardiology. MeetbaarBeter contributed to the clinical aspects and medical knowledge of the bundle with their expert opinion. Table 3 gives an overview of the different phases for designing the model and how data was collected for each phase. The phases are based on the theoretical framework.

Table 3. Overview of the phases for designing the model

Phase	Collected from		
	Literature search	Menzis claims data	MeetbaarBeter
1. Defining the patient			√
2. Defining timeframe	√		
3. Defining content	√	√	√
4. Defining bundle tariff (case-mix corrected)	√	√	√
5. Defining bonus tariff	√	√	√

The use of Menzis claims data is discussed first, followed by the data analyses of each phase.

Menzis claims data

Claims data from Menzis consists of demographic data (including age, gender, etc.), medication use, DRGs claimed by hospitals and health care activities (HCAs). HCAs are specific services that are registered by hospitals. Different combinations of HCAs result in different diagnosis-related-groups (DRGs). Each DRG does not only consist of services, it is also registered with a certain diagnosis (i.e. diagnose code).

Only DRGs have tariffs and can therefore be claimed by hospitals. As an example, the combination of the HCA *'acute PCI'* and a certain amount of the HCA *'hospital days'* results in the DRG *'PCI class 4 with hospital days'*.[46] A possible diagnose code linked to this DRG is a STEMI[viii] (i.e. acute heart attack). In 2015 this specific DRG had an average tariff of €7,390.[47] For more information on the DRG-system and claims data see appendix B.

Selection of patients

Claims data were used of patients, insured by Menzis, who underwent a PCI between January 1 and June 30, 2015. This period was chosen for several reasons. First, as of January 1, 2015 hospitals are obligated to communicate registered HCAs to health insurers. Second, the integration of physician fees into DRGs was initiated on January 1, 2015 as well. Before this date, some physicians received a separate payment for their services. Third, the deadline for claiming DRGs over 2015 was January 1,

[viii] STEMI = ST-elevated myocardial infarction. An acute heart attack with significant abnormalities on the electrocardiography (ECG).

2017. By choosing this specific period it was certain that all DRGs within the first 6-months of 2015 were included in the claims database. The following patients were excluded from the dataset:

- patients who were not insured with Menzis in 2014; these patients claims history was not available
- patients who underwent a PCI in a 6-month period prior to the PCI in 2015; this meant that the PCI between January 1 and June 30, 2015 was not the first PCI but rather additional
- patients who underwent an expensive diagnostic coronary angiography which were claimed as a PCI-DRG[ix,44]; these patients did not undergo a coronary intervention

DRGs claimed

Of these patients all the DRGs, in a 6-month period after the initial PCI, claimed by the cardiology and cardiothoracic surgery department were isolated. This included all inpatient hospital care and outpatient hospital care (i.e. DRGs linked to follow-up care). Then, the total claimed tariff of each patient in this period was calculated (including the tariff claimed for the initial PCI) (Table 4). In addition, claimed intensive care unit (ICU) days up to three days after the initial PCI were included since ICU-days are claimed separately and are not part of the DRGs claimed by the cardiology and cardiothoracic surgery departments.

Note: these prices do not represent the actual costs of the services provided but are a result of negotiations between providers and insurers. Since the tariff of each DRG differs between providers, the average tariff per DRG of 2015 was used, irrespective of the hospital setting (e.g. academic hospitals and small regional hospitals).[47]

Case-mix variables

The case-mix variables that were available for adjusting the bundled payment tariff are described in Table 4. These case-mix variables were chosen for their similarity to the variables used by MeetbaarBeter for their case-mix correction on outcome and are therefore based on expert opinion.[44] It was assumed that these variables would influence the quantity and the total claimed tariffs of DRGs. The variable *academic hospital* was added for the assumption that academic hospitals most often treat more complex patients and are required to claim more DRGs. The case-mix variables were derived from different parts of the Menzis claims data (i.e. the demographic data, the diagnosis linked to the claimed DRG or HCA-data). See appendix C for an overview of available MeetbaarBeter variables in relation to the available Menzis variables.

[ix] Expensive diagnostic coronary angiographies include IVUS (IntraVascular UltraSound), FFR (Fractional Flow Reserve) and OCT (Optical Coherence Tomograph). These angiographies can be claimed as a PCI-DRG without intervention taking place.[46]

Table 4. Variables available for the design of the bundle

Total tariff of DRGs claimed	Type of value	Derived from
Claimed tariff, including: *- Initial claimed PCI* *- Follow-up claims* *- ICU claims*	*Euros*	*All cardiology and cardiothoracic claims data 6-months after initial PCI (only ICU-claims within 3 days of the initial PCI were included)*
Case-mix variable	**Type of value**	**Derived from**
Age	*In years*	*Demographic data*
Gender	*0 = male* *1 = female*	*Demographic data*
Initial PCI category *1. Acute setting* *2. Elective PCI of a single artery* *3. Elective PCI of a chronic total occlusion* *4. Elective PCI of the left main coronary artery or multiple arteries*	*categorical*	*HCA-data linked to initial PCI*
Diagnosis leading to initial PCI *1. ST-elevated myocardial infarction (STEMI)* *2. Non ST-elevated myocardial infarction (NSTEMI)* *3. Other*	*categorical*	*Diagnose code linked to initial PCI*
Diabetes	*0 = no* *1 = yes*	*Claimed medication data; 6-months prior to initial PCI*
Kidney failure	*0 = no* *1 = yes*	*6-months prior to initial PCI*
Academic hospital	*0 = no* *1 = yes*	*DRG claims data*
Quality outcome variable	**Type of value**	**Derived from**
Mortality	*0 = no* *1 = yes*	*Demographic data (all causes, 6-months after initial PCI)*
Admittance to ICU	*0 = no* *1 = yes*	*ICU claims data (admittance within 3 days of initial PCI)*
Ischemic stroke or transient ischemic attack	*0 = no* *1 = yes*	*DRG claims data (within 6-months after initial PCI)*
Extra PCI, in addition to initial PCI	*0 = no* *1 = yes*	*HCA-data (within 6-months after initial PCI)*
Coronary artery bypass grafting (CABG)	*0 = no* *1 = yes*	*HCA-data (within 6-months after initial PCI)*

PCI = percutaneous coronary intervention; ICU = intensive care unit; HCA = health care activity; DRG = diagnosis-related-group

Quality outcome variables

The selected outcome variables are in Table 4 as well. As with the case-mix variables, these variables were chosen for their similarity to the quality metrics used by MeetbaarBeter (appendix C) and for their importance on patient relevant outcome. The important difference, however, is that outcome variables of MeetbaarBeter are directly linked to the initial treatment whereas Menzis claims data are not. For example, MeetbaarBeter registers whether an extra PCI was in the same coronary artery as the initial PCI (i.e. target vessel revascularization, TVR). Menzis claims data, on the other hand, only indicates whether an additional PCI has been claimed, regardless if this was linked to the initial PCI. The outcome variables were derived from different parts of the Menzis claims data (i.e. the demographic data, the diagnosis linked to the claimed DRG or HCA-data). The outcome variables are

primarily indicators of resource utilization and events and not patient-reported outcomes (i.e. quality of life or patient satisfaction).

Data analyses of Menzis claims data

The dataset derived from Menzis claims data was analyzed to determine the content of the bundle, to calculate a case-mix corrected tariff for the content of the bundle and to calculate the bonus tariff based on quality outcomes.

Defining the content

Together with the literature, the Menzis claims data give an insight in the procedures and services of care provided in the 6-month period after the initial PCI. The frequency of services provided, including HCAs and DRGs, was calculated in Microsoft® Excel 2016™; no statistical analysis was performed on this data.

Defining the bundle tariff (case-mix corrected), patient specific

First, a descriptive analysis was done of the determined content of the bundle and its corresponding claimed tariff. These descriptive statistics were generated by using Microsoft® Excel 2016™ and include the claimed tariffs of: the initial PCI, follow-up care and of ICU admissions. Second, SAS® Enterprise Guide 9™ was used for the case-mix correction on the Menzis claims data. Multiple linear regressions models were estimated, using the total claimed tariff, within the determined time-frame, as the dependent variable and the case-mix variables as independent variables. New variables were computed using the variables in Table 4 after analyzing the descriptive statistics, to maximize the explained variance of the model (R^2). Outliers of the total claimed tariff were removed. Outliers were removed because these patients are also expected to be excluded in the final model due to a possible stop-loss agreement.[x] The definition of outliers was based on the literature search.

To investigate the appropriateness of using a multivariate linear regression, the assumptions underlying this regression were tested, including a linear relationship, homoscedasticity and absence of multicollinearity. All case-mix variables were included into the predictive model, unless the variable did not attribute to the explained variance (R^2). When the linear regression model is created, a patient specific bundle tariff can be calculated based on the characteristics of the patient.

Defining the bonus tariff (case-mix corrected), hospital specific

Adding the bonus (or penalty) tariff to the bundle was done in three steps (Figure 2).

[x] A stop-loss model is the full reimbursement of costs, of an individual patient, that exceed a predetermined amount. A stop-loss agreement can be used to prevent adverse patient selection, in addition to case-mix correction, since providers will not bear financial risks to exceptionally expensive patients. See also the theoretical framework chapter.

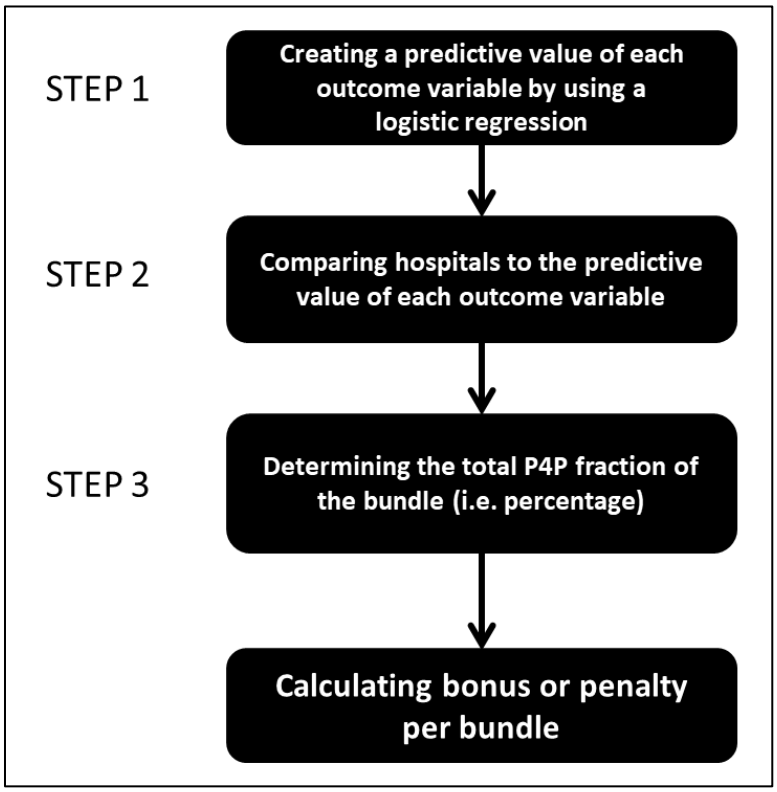

Figure 2. The three steps in determining the bonus tariff for quality.

First, of the total Menzis claims dataset a prediction model was created for each outcome variable (i.e. the dependent variable), based on the data from all the hospitals. In other words, the predictive value was calculated from all the hospitals combined; hence creating a benchmark value in relation to the case-mix variables. All outcome variables are dichotomous and therefore a multiple logistic regression was done on each outcome variable. Both regressions had the case-mix variables as independent variables, so that the predicted value is adjusted for the case-mix of a hospital. All case-mix variables of Table 4 were included, unless it did not attribute to the c-statistic. No outliers were removed. Assumptions for a logistic regression were tested and reported. When the logistic regression model is created, prediction of performance can be calculated based on the case-mix of the hospital. In the second step, the predictive model from step one was used to compare the predictive values of each of the outcome variables to the actual values. This difference in performance was described as relative rather than absolute.[48] The third and final step was determining the fraction of the bundle that was designated to the bonus or penalty. Again, this fraction of P4P could either be a relative amount or absolute amount. In line with Van Herck et al. (2011) a relative fraction (i.e. percentage) was chosen for this model.[48] SAS® was used to accomplish step 1. The calculations for steps 2 and 3 were done using Microsoft® Excel 2016™.

Results

Previous experiences of bundled payments for PCI

Out of 41 articles found in the literature search, a total of six bundled payment programs containing PCI were found and analyzed. [49,24] All of the programs have their origin in the US. The most important findings are mentioned in Table 5. See appendix D for more details on each program.

Time-frame

Most of the programs include a time frame between 30 and 90 days after initial treatment. The PROMETHEUS® project is the only program with a 180-day period for elective PCIs. [50] Three programs also extended the time-frame prior to the PCI to include the diagnostic tests leading to a PCI, such as the Arkansas program. [50,51,59]

Content of bundle

An explicit distinction between an acute and elective treatments is made in each program. An episode of an acute PCI is defined by either the treatment itself or by the acute myocardial infarction (AMI) diagnosis. Each program includes only the care (e.g. complications) that is directly linked to the initial treatment or diagnosis. In most programs these specific complications had to be registered by the providers as such during the bundle or were agreed beforehand by the providers and payers. Except for the Centers for Medicare & Medicaid® (CMS) programs, all programs include only hospital care. The program of Episode Payment Models™ by CMS, to be launched in 2017, also explicitly defines around 1200 diagnoses that are not included in the bundle. [52]

Case-mix correction and exclusion

Two out of the six programs have a bundle tariff that is (partially) based on risk-adjustment. The PROMETHEUS program contains a risk-adjustment for the bundle and an extra risk-adjusted allowance of the pre-defined *'Potentially Avoidable Complications'* (PACs).[53] For these complications providers receive a prospective payment so that the prevention of an avoidable complication results in a bonus. Risk-adjustment is based on patient demographics, severity of illness and comorbidities. [54] The Tennessee program uses an '*Episode Risk Score'* to adjust the tariff.[49, 55] In this program every case-mix variable has a different weight that determines the tariff. For example, in acute PCIs age has a weight of 0.001, female and male have weights of 0.842 and 0.878 respectively, while respiratory failure has a weight of 0,193.[55] Each of the programs does have exclusion criteria to prevent adverse patient selection. Half of the programs exclude patients who are 65 years of age and above. In addition, some programs exclude patients who significantly deviate from a pre-defined path of care for PCI or cause outliers in costs (i.e. a stop-loss agreement). For instance, within the Arkansas program any patient whose costs are more than three standard deviations above the average costs is excluded from the

program.[51] Also, although not on a patient level but on a hospital level, the Episode Payment Models by CMS have agreements to protect hospitals from excessive financial risk. There is a stop-loss limit of 5% on the total budget in year 1, 2 and 3, 10% in year 4 and 20% in year 5 (i.e. the losses above this percentage are paid by the CMS). [56]

Use of quality metrics

All six programs include registration of quality indicators, which are mainly structural and process measurements. The Bundled Payments for Care Improvement™ (BPCI) by CMS is the only program that added patient experience to these indicators.[57] However, there is no relationship between the performance on the quality metrics and payment, in contrast to all of the other programs which do have some form of pay-for-performance (P4P). The P4P in the five other programs was either implemented through withholding payment if quality thresholds were not met or by adding a bonus to the tariff, such as the PCI ProvenCare Initiative™ or the Episode Payment by CMS.[58,56] In all of the six programs, quality metrics were risk-adjusted.

Tariff calculation and payment

Every program has a tariff which is based on historical claims data and not on current actual costs. In most programs the payment of the bundle tariff is done prospectively, with some form of retrospective correction, but the PROMETHEUS program includes a retrospective payment based on the case-mix of the treated population.[49] The newer programs, from 2014 onwards, all include gain-sharing and/or loss-sharing agreements. In other words, when costs are lower (or higher) than expected the gains (or losses) are shared between provider and payer. [59]

Results of the programs

There have not been many published evaluations of the six programs. Especially, data on the more recent programs are lacking. The evaluation reports that were available did not describe PCI specifically but the concept and implementation of the program in general, which most often consists of many different diagnoses and treatments. These reports describe difficulties with the amount of data that had to be registered and with the complexity of the programs.[60,61] For instance, in the PROMETHEUS program, where complexity was associated with the question whether a readmission or complication was related or unrelated to the initial PCI.[60] The ProvenCare Initiative did experience a reduction in length-of-stay and an increase in preferable access site for PCI (i.e. the radial artery).[49] The new CMS-program still has to be implemented but it has already been criticized in some journals. Song & Blumentahl (2016), for example, discuss that physicians might not be incentivized to focus on long-term outcomes when a time-frame is 90-days or shorter. They also address a risk of a reduction in treatments in high risk patients due to the absent of appropriate risk-adjustment. [62]

Table 5. Overview of programs of bundled payments for PCI

Year of intro-duction	Program	Time-frame	Content	Case-mix correction / exclusion criteria	Use of quality metrics	Tariff calculation and payment	Results
2005	Geisinger Health System® (GHS) PCI ProvenCare Initiative™	90-days post-discharge	elective PCI's and follow-up care (designed by cardiologists) incl. pre-operative evaluation, all hospital and professional fees, routine post-discharge care, and management of related complications	Limited exclusion criteria but no separate risk-adjustment payment	40 quality indicators (process elements). quality metrics are risk stratified for the P4P model	Prospective payment and price was based on historical data directly linked to quality measurements	A decrease in total length of stay (LOS) was registered from 2.86 days to 2.50 and post-procedural from 2.27 to 1.69 and use of PCI via the radial artery (preferred access) increased from 34% to 80%
2006	PROMETHEUS®/ Health Care Improvement Initiative Institute™	60-days prior to admission and 180-days post-discharge for elective PCI and 30-days after an acute myocardial infarction (AMI).	Elective and emergent (acute) PCI treatments. A distinction is made for necessary care (typical costs) and potentially avoidable complications (PACs)	For the allowance of PACs, severity adjustment is applied. This includes: comorbidities, patient-demographics, historic risk factors and clinical severity markers. Exclusions are present such as: age <18 and >64 years, patients with cancer, HIV or end-stage renal disease. Stop-loss can be added.	The higher the costs of PACs, the lower the assumed quality. Additional P4P can be added if agreed upon between insurer and provider	Payment is done prospectively but payment for risk-adjustment is done retrospectively. For each episode: cost of typical care, expected cost of complications, allowance for underuse, PAC's allowance and an additional margin.	The implementation of model experienced major challenges because of the complexity of the model. No specific evaluation for PCI treatments
2013	Centers for Medicare & Medicaid® (CMS): Bundled Payments for Care Improvement™ (BPCI) Model 4*	30-days post-discharge	Episodes include AMI or a PCI treatment and all services within the hospital linked to the initial treatment (e.g. readmissions). Each episode includes a gathering of multiple DRGs	Exclusion: patients with End Stage Renal Disease. CMS also provides additional payments for outliers (not further defined). No other form of risk-adjustment is used.	CMS record quality metrics such as patient experience, patient safety, complication rate, mortality and readmission (no consequences for bundle)	Costs are based on three years of historical claims data and separate payments for medical education, disproportionate share hospital and capital payments are provided.	Only few hospitals participated and 50% dropped out because of the amount of data files hospitals received from CMS. No details for PCI available.
2014	Tennessee Health Care Improvement Innovation Initiative™	Non-acute PCI: 90-days prior to admission and 30-days after. Acute PCI: 30-days post discharge.	2 episodes: non-acute PCI and acute PCI. Only costs that are related to the PCI are included.	Examples of exclusion: episodes which deviate significantly from regular care path, >64 years old, acute CABG needed, cardiogenic shock, death. Risk-adjustment is present. Risk-factors are provider specific and an 'Episode Risk Score' is used for the tariff.	Payment is not based on quality metrics but payment is only done when certain quality thresholds are reached. Quality metrics are risk adjusted	Payment is based on historical claims data that is risk adjusted. Gain- and risk-sharing of 50% is applied	No evaluation reports have been found specifically on PCI
2015	Arkansas Health Care Payment Improvement Initiative™	30-day post procedure. If a diagnostic angiogram is performed prior to the PCI, care within 30 days prior PCI is included.	PCI treatment and all the facility services linked to the initial treatment, including medication.	No payment for risk-adjustment is added. Some exclusions, e.g.: 65 years of age and above, acute CABG within one day, outliers in costs and a list of 55 co-morbidities which are present in claims data within 365 days before procedure.	Including adverse outcomes within 30 days after procedure (e.g. AMI, stent thrombosis, wound infection, pulmonary embolism).	Based on claims data and an additional reimbursement is done for complications. Gain- and loss-sharing is applied and dependent on quality metrics.	Currently no evaluation present.
2017 (planned)	Centers for Medicare & Medicaid® (CMS): Episode Payment Models™	90-days post discharge.	All services linked to the hospitalization for AMI (which is also initiated by a PCI in acute setting) is included, specialist as well as non-hospital care. Defined and unrelated services are excluded (approximately 1200 diagnoses).	Small urban regions, with population of less than $50.000, are not eligible for the program. Actual payment is not risk-adjusted	30-day mortality rate (all-cause), excess days in acute hospitalization and patient experience. If a certain standard of quality is not met payments will not be provided. Quality-metrics are risk-adjusted.	bundle tariff is paid prospectively (target price), based on retrospective claims data and a bonus or penalty may be applied retrospectively for quality. a stop-loss and stop-gain limit of 5% in year 1, 2 and 3 and 10% in year 4 and 20% in year 5	The program has not yet been implemented but has been criticized. physicians might not focus on long-term outcomes (due to the short 90-day period) and there is a risk in reduction of treatments in high risk patients due to the absent of risk-adjustment

*AMI = acute myocardial infarction; CABG = coronary artery bypass graft surgery; CMS = Centers for Medicare & Medicaid; DRG = diagnosis-related-group; PACs = potentially avoidable complications; PCI = percutaneous coronary intervention; *BPCI Model 4 was chosen since it only contains hospital services, in line with this report.*

The design of the bundled payment model

The actual design of the bundled payment model for PCI is described in this section. The results are derived from literature on PCI and bundled payments, Menzis claims data and expert opinion (Table 3). First, an overall description of the used claims data is presented. Then, the results for the design are presented in the 5 phases defining: the patient (1), the time-frame (2), the content (3), the case-mix corrected tariff (4), the bonus tariff (5). The results section ends with an example on how the final tariff can be calculated.

Overview of Menzis claims data

The descriptive statistics of the Menzis claims dataset are shown in Table 6. A total number of 2135 patients was used. The dataset included 31 different Dutch hospitals, and the number of patients per hospital ranged from 7 to 437. The average amount of money claimed by hospitals, over a six month period after the initial PCI, was €10,590.19 (±6,779.66) and the distribution was skewed to the right. In 13.68% and 3.75% of the patients one (or more) extra PCIs and CABGs were claimed, respectively. Table 7 shows the differences in case-mix and claimed tariff between acute and elective PCIs. In this table it can be seen that there is a considerable difference in the total claimed tariff and that, in particular, there is a substantial difference in the case-mix variables *'diabetes'* and *´diagnosis category' (i.e. 'STEMI', 'NSTEMI', 'other diagnosis).*

Table 6. Descriptive statistics of the Menzis claims dataset

Total number of patients						
n =	2135					
Total claimed tariff of DRGs*		*Mean*	*Std Dev*	*Minimum*	*Maximum*	*Median*
Claimed tariff *(in euro's)*		€ 10,590.19	€ 6,779.66	€ 3,195.00	€ 71,595.00	€ 8,620.00
Case mix	*Percentage*	*Mean*	*Std Dev*	*Minimum*	*Maximum*	
Age *(years)*		64.74	11.40	30	100	
Female *(%)*	27.92%					
Acute PCI *(%)*	47.31%					
Elective, PCI, single artery *(%)*	30.49%					
Elective PCI, chronic total occlusion *(%)*	6.09%					
Elective PCI, multiple arteries or LMA *(%)*	14.00%					
Elective PCI, corornary graft *(%)*	2.11%					
STEMI *(%)*	31.99%					
NSTEMI *(%)*	19.58%					
Other diagnosis *(%)*	48.43%					
Diabetes *(%)*	21.03%					
Kidney failure *(%)*	2.01%					
Initial PCI in academic hospital *(%)*	28.81%					
Quality Outcome	*Percentage*					
Mortality *(within 6 months, all causes) (%)*	3.70%					
ICU admission *(within three days) (%)*	4.59%					
Ischemic stroke or TIA *(within two weeks) (%)*	0.56%					
One or more extra PCIs needed *(per patient)(%)*	13.68%					
One or more CABGs needed *(per patient)(%)*	3.75%					

**Total claimed tariff of DRGs includes claims of PCI / claims follow-up care/ claims ICU-stay (up to 3 days); Percentages represent the prevalence of case-mix and quality outcome variables. PCI = percutaneous coronary intervention; LMA = left main artery; STEMI = ST-elevated myocardial infarction; NSTEMI = Non-ST-elevated myocardial infarction; ICU admission = percentage of patients admitted to the ICU within three days after initial PCI; TIA = transient ischemic attack; CABG = coronary artery bypass graft surgery*

Table 7. Descriptive statistics of the Menzis claims dataset (acute vs elective PCI)

Total number of patients *n* = 2135

	ACUTE		ELECTIVE	
Number of patients *(n)*	*n* = 1010		*n* = 1125	
Variable	*Mean*	*Std Dev*	*Mean*	*Std Dev*
Claimed tariff *(in euro's)*	€ 12,507.68	€ 6,510.11	€ 8,868.70	€ 6,553.64
Age *(years)*	63.06	12.15	66.26	10.47
	Percentage		*Percentage*	
Female *(%)*	27.33%		28.44%	
Elective, PCI, single artery *(%)*	n/a		57.87%	
Elective PCI, chronic total occlusion *(%)*	n/a		11.56%	
Elective PCI, multiple arteries or LMA *(%)*	n/a		26.58%	
Elective PCI, corornary graft *(%)*	n/a		4.00%	
STEMI *(%)*	63.96%		3.29%	
NSTEMI *(%)*	22.67%		16.80%	
Other diagnosis *(%)*	13.37%		79.91%	
Diabetes *(%)*	14.85%		26.58%	
Kidney failure *(%)*	1.19%		2.76%	
Initial PCI in academic hospital *(%)*	26.14%		31.20%	
Mortality *(within 6 months, all causes) (%)*	4.75%		2.76%	
ICU admission *(within three days) (%)*	8.12%		1.42%	
Ischemic stroke or TIA *(within two weeks) (%)*	0.89%		0.27%	
One or more extra PCIs needed *(per patient)(%)*	15.84%		11.73%	
One or more CABGs needed *(per patient)(%)*	5.25%		2.40%	

PCI = percutaneous coronary intervention; LMA = left main artery; STEMI = ST-elevated myocardial infarction; NSTEMI = non-ST-elevated myocardial infarction; ICU = intensive care unit; TIA = transient ischemic attack; CABG = coronary artery bypass graft surgery

The design of the model

1. Defining the patient

The patient is defined by using MeetbaarBeter's following definition: any patient, older than 18, who receives a PCI or attempted PCI, in any setting (i.e. acute or elective) and in any type of artery (i.e. normal coronary artery or bypass graft).[44] Thus, a PCI can be due to a STEMI, NSTEMI, persistent angina pectoris or any other cause. Also, a PCI can be done in one coronary artery or in multiple arteries. Because of the well-defined beginning of a PCI, the definition of a patient is based on a patient undergoing a treatment rather than having a diagnosis (e.g. AMI, atypical chest pain).[23] The PCI must be the first PCI within a 6-month period in order to start a new bundle, this was due to the time-frame (see phase 2). There is an exclusion criterion for outliers in costs (see phase 4), but no other patient specific exclusion criteria are used (e.g. maximum age, comorbidities, medical history).

2. Defining the time-frame

Figure 3 illustrates the cumulative percentage of the total claimed tariff of the Menzis claims dataset, within a six-month period. This figure shows that most of the total claimed tariff pertains to a period within 30 days after the initial PCI. It is for this reason that programs in the past have focused on this 30-day period, although some were chosen having a 90-day period (Table 5). Our current model,

however, will include cardiac care within a 183-day period after the initial PCI (i.e. six months). A longer term was chosen to incentivize physicians to focus on preventive measures and improve care for the long term.[62,63] This is especially relevant in the case of PCI, where cardiac rehabilitation, long term medication use and secondary prevention (i.e. lifestyle changes) are needed to prevent complications and new cardiac events.[64]

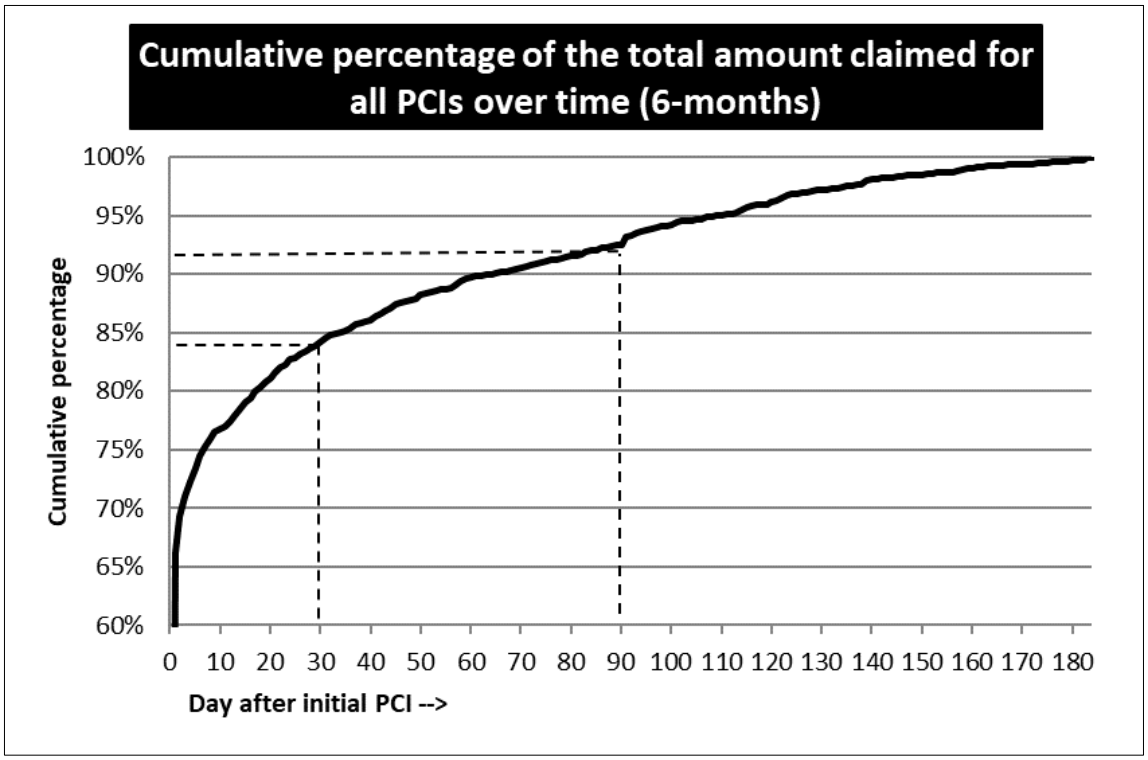

Figure 3. Cumulative percentage of the total DRG-tariff claimed

3. Defining the content

Table 8 and Table 9 show the most frequently claimed DRGs within a 6-month period after the initial PCI. These DRGs are all of the DRGs claimed by the cardiology and cardiothoracic surgery department within that period, so irrespective of an association to the initial PCI. In Table 8 the DRGs that account for the largest share of the total costs are shown. The DRG which contributed the most to the total claimed amount was DRG 14D678 'PCI class 4', which is the DRG that is linked to an acute PCI. DRG 14D654, a DRG for a transcatheter aortic valve implementation (TAVI), was claimed in only 0.75% of the patients but due to its tariff, it accounts for 2.17% of the total amount claimed. DRGs for outpatient care, which contribute substantially to the total amount and are claimed most frequently (Table 8 resp. Table 9) are the DRGs for cardiac rehabilitation (e.g. 15E633, 15E631) and follow-up after PCI (e.g. 15B365, 15B357).

Table 8. DRGs contributing most to the total amount claimed (=€21,896,675)

DRG-code	DRG-description	DRG-tariff	Freq. per patient (%)	Percentage of total claimed (%)
14D678	PCI class 4, including hospital admission	€ 7,390.00	46.93%	33.82%
14D682	PCI class 2, including hospital admission	€ 6,765.00	18.41%	12.14%
14D684	PCI class 1, including hospital admission	€ 5,125.00	16.11%	8.05%
14D683	PCI class 2, not including hospital admission	€ 4,205.00	8.90%	3.65%
14D680	PCI class 3, including hospital admission	€ 6,870.00	5.25%	3.51%
14D685	PCI class 1, not including hospital admission	€ 3,195.00	9.60%	2.99%
15B702	Ischemic heart disease with damage, including short length hospital admission	€ 2,710.00	9.32%	2.46%
14D654	TAVI class 3, including hospital admission	€ 29,665.00	0.75%	2.17%
15B704	Ischemic heart disease with damage, including average length hospital admission	€ 5,845.00	3.51%	2.00%
14D665	CABG, least complex	€ 11,000.00	1.59%	1.71%
15E633	Not complex heart rehabilitation, more than 6 sessions	€ 1,075.00	16.07%	1.68%
14D699	ICD implementation	€ 20,075.00	0.84%	1.65%
14D664	CABG, medium complex	€ 11,240.00	1.36%	1.49%
14D679	PCI class 4, excluding hospital admission	€ 4,585.00	3.23%	1.44%
15E631	Not complex heart rehabilitation, more than 6 sessions, with paramedic assistance	€ 1,415.00	10.16%	1.40%
15B357	Follow-up after CABG/PCI, including hospital admission	€ 1,805.00	7.78%	1.37%
15E635	Not complex heart rehabilitation, intake	€ 665.00	19.72%	1.28%
15B356	Follow-up after CABG/PCI, outpatient treatment, medium complex	€ 395.00	29.46%	1.13%
15A613	Ischemic heart disease without damage, including short length hospital admission	€ 1,800.00	6.18%	1.09%
14D681	PCI class 3, not including hospital admission	€ 4,495.00	2.34%	1.03%

Includes all claims by cardiology and cardiothoracic surgery department that are made in a 6-month period after initial PCI (minimum of 1% of total amount claimed); Freq per patient = e.g. DRG 14D678 was claimed in 46.93% of the patients; Percentage of total claimed = e.g. DRG 14D678 contributed to 33.82% of the total claimed tariff of all patients combined (=€21,896,675). Table is sorted on 'percentage of total claimed'; PCI = percutaneous coronary intervention; TAVI = transcatheter aortic valve implementation; CABG = coronary artery bypass graft surgery; ICD = implantable cardioverter defibrillator;

Table 9. DRGs most claimed

DRG-code	DRG-description	DRG-tariff	Freq. per patient (%)	Percentage of total claimed (%)
14D678	PCI class 4, including hospital admission	€ 7,390.00	46.93%	33.82%
15B365	Follow-up after CABG/PCI, outpatient treatment, least complex	€ 180.00	38.92%	0.68%
15B356	Follow-up after CABG/PCI, outpatient treatment, medium complex	€ 395.00	29.46%	1.13%
15B739	Heart team consultation	€ 170.00	26.93%	0.45%
15E635	Not complex heart rehabilitation, intake	€ 665.00	19.72%	1.28%
14D682	PCI class 2, including hospital admission	€ 6,765.00	18.41%	12.14%
14D684	PCI class 1, including hospital admission	€ 5,125.00	16.11%	8.05%
15E633	Not complex heart rehabilitation, more than 6 sessions	€ 1,075.00	16.07%	1.68%
15B358	Follow-up after ACS, outpatient treatment, least complex	€ 170.00	15.22%	0.25%
15B354	Follow-up after ACS, outpatient treatment, medium complex	€ 420.00	12.79%	0.52%
15A610	Ischemic heart disease with/without damage, outpatient treatment, medium complex	€ 530.00	12.55%	0.65%
15A611	Ischemic heart disease with/without damage, outpatient treatment, least complex	€ 185.00	11.01%	0.20%
15E631	Not complex heart rehabilitation, more than 6 sessions, with paramedic assistance	€ 1,415.00	10.16%	1.40%

Includes all claims by cardiology and cardiothoracic surgery department that are made in a 6-month period after initial PCI (minimum of 10% per patient). Freq per patient = e.g. DRG 14D678 was claimed in 46.93% of the patients; Percentage of total claimed = e.g. DRG 14D678 contributed to 33.82% of the total claimed tariff of all patients combined (=€21,896,675). Table is sorted on 'Freq. per patient'; PCI = percutaneous coronary intervention; CABG = coronary artery bypass graft surgery; ACS = acute coronary syndrome

Although the claims data mentioned in Table 8 and Table 9 only consist of claims that are made after the initial PCI by the cardiology or cardiothoracic surgery departments, they do not make a distinction between claims that are related to the initial PCI and those that are not. All of the programs mentioned in Table 5 do include specifically, and only, treatments (e.g. complications, readmissions) in the bundle which are directly associated with the initial PCI. However, as evaluated, it was difficult to determine which treatment was actually linked to the initial PCI and which was not. This is due to differences in opinion about the causal-relationship to the initial PCI and the amount of administrative work which would be needed to determine this relationship (as in the BPCI-program).[61] In addition, a decision on whether a complication is avoidable or not is very difficult to make, as was seen with the '*potentially avoidable complications (PACs)*' in the PROMETHEUS program. [60,65] So instead of defining which additional treatments within the 6-month period are associated with the initial PCI, all care performed by the cardiology and cardiothoracic surgery departments were included.

As an example, an extra PCI within the 6-month period can be due to a stenosis in a different carotid artery (i.e. not linked to the initial PCI). In a non-acute setting, this extra PCI would probably have been performed simultaneously with the initial PCI (i.e. increasing efficiency and reducing costs). Evidence suggests that performing an elective PCI with revascularization of multiple arteries simultaneously does not differ in quality to staged revascularization (i.e. multiple PCIs).[66] So by not focusing on whether an extra PCI is associated with the initial PCI, providers are incentivized to perform a one-time revascularization instead of staged to improve efficiency. However, there are treatments which are most likely not associated with the initial PCI but are expensive and still need to be performed within the bundle time-frame. This is for example the case with a TAVI procedure or the implementation of an implantable cardioverter defibrillator (ICD) (DRG 14D699, Table 8). Providers bear substantial financial risks with these expensive treatments even though they can be unrelated to the initial PCI. Ideally, they should be excluded from the bundle beforehand, but since these treatments are expensive and therefore one the main concerns for large financial risks, they will be in the outlier category or above the stop-loss agreement (see phase 4). And so, providers do not need to bear the extra financial risks for these expensive treatments.

In addition to Table 8 and Table 9, Table 10 illustrates the health care activities (HCAs) which are most frequently registered within six months after the initial PCI. Although HCAs cannot be claimed and are not associated with a tariff, this table does describe the sort of care that is provided within this period. For example, the average length-of-stay in a 6-month period after the initial PCI is 5.78 days per patient.

Table 10. HCAs most registered

HCA-code	Description	Total number registered	Average number registered per patient
39757	Interpretation ECG, Holter, bicycle stress test, etc.	13778	6.45
190218	In-hospital day	12345	5.78
193140	Cardiac rehabilitation session (FIT)	10019	4.69
190013	Follow-up outpatient visit	4145	1.94
190060	First outpatient visit	2646	1.24
190961	Physiotherapy - directly linked to patient - rehabilitation	2305	1.08
85002	Chest X-ray	2181	1.02
193001	Individual session physiotherapy	1977	0.93
39494	Echocardiogram (ultrasound of the heart)	1920	0.90
39844	Simple bicycle stress test, seperate session	1663	0.78
33229	Cardiac catheterization (incl angiography)	1655	0.78
193126	Consultation for intake	1283	0.60
39843	Telemetry of heart activity	1193	0.56
193004	Group session physiotherapy (5-10 people)	1159	0.54
33238	Acute PCI for treating coronary stenosis	1116	0.52
190940	Physiotherapy - indirectly linked to patient - rehabilitation	1075	0.50

Within a 6-month period after initial PCI (minimum of 0.5 per patient); *n = 2135; total number registered = total amount of the HCA that is registered; average number registered per patient = e.g. average amount of hospital days per patient was 5.78; ECG = electrocardiography*

4. Defining the bundle tariff (patient specific)

The patient specific bundle tariff was calculated by using a multiple linear regression model. Before estimating this regression model, 452 patients were excluded as outliers; a total of 1683 (=2135-452) patients was thus included into the analysis. Outliers were defined as patients whose total of all tariffs claimed was more than €12,708.23. The threshold of €12,708.23 is 120% of the mean of the total tariff claimed of all patients in the database (€10,590.12*120% = €12,708.23; Figure 4). The limit of 120% was based on the BPCI program by CMS.[67] In this program, CMS ensures payment when actual costs exceed 20% of the amount the bundle predicted. Therefore, a threshold of €12,708.23 for the outliers was chosen for the model in this report (i.e. 120% of the mean). This automatically means that this bundled payment model has a stop-loss agreement of €12,708.23. In other words, when the total of all claims exceeds this amount, the services provided will not be financed through the bundle but it has to be financed in a separate way (e.g. the traditional DRG-system). Figure 4 shows this threshold and the distribution of the total tariff per patient of all the DRGs claimed within a 6-month period. This tariff includes all DRGs claimed by the cardiology and cardiothoracic surgery department as well as the first three days of ICU admittance after the initial PCI.

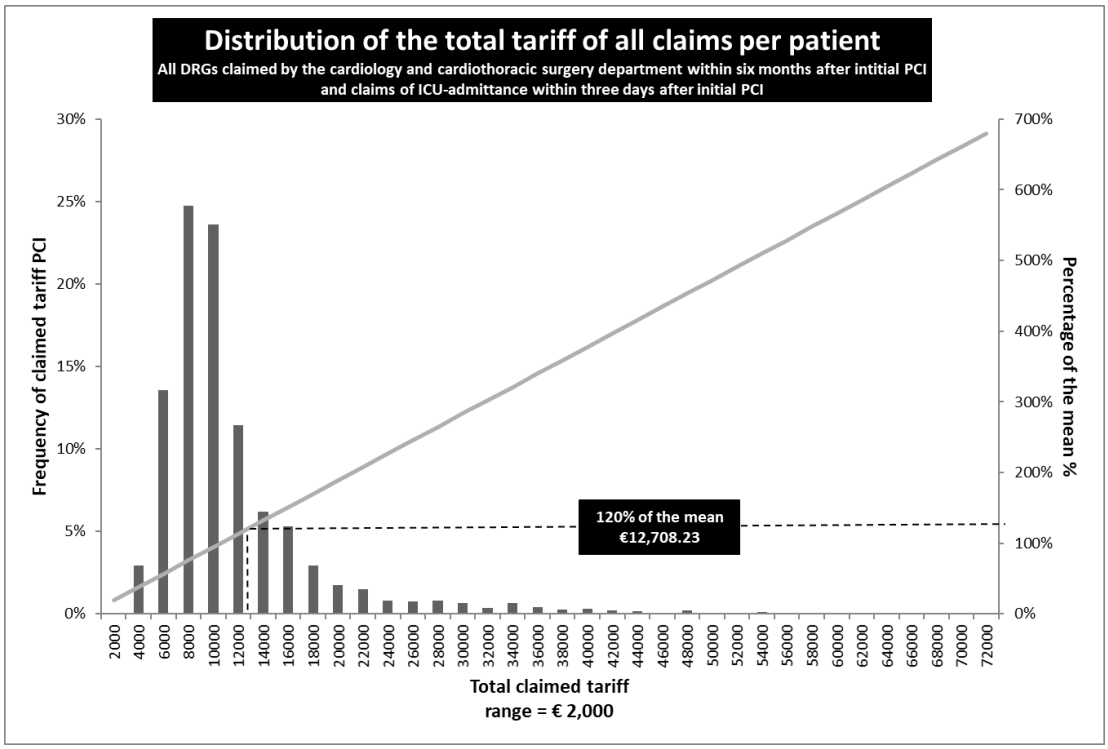

Figure 4. Distribution of total tariff claimed per patient

Table 11 shows the case-mix predictive model for the bundle tariff. The dependent variable was defined as the total sum of all DRGs claimed, per patient and within a 6 months period after the initial PCI (Table 4). As predictor variables all of the case-mix variables described in the Methods section were used due to the clinical relevance and the contribution to the explained variance. For the computing of the dummy variables of the categorical variable '*Initial PCI category'*, the category *'Elective PCI of a single artery'* was used as the reference variable. This category contributed the least to the outcome variable and, in addition, this category can be considered as the least difficult procedure. The categorical variable of *'diagnosis leading to initial PCI'* was computed into the dummy variables *'STEMI'* and *'NSTEMI'.* The category *'other diagnosis'* was used as the reference variable since this was the category with the largest number of patients (48%; Table 6) and contributed the least to the predicted outcome.

To improve the predictive value of the model, the variable '*Elective PCI & diabetes'* was computed, based on the clinical importance diabetes has in elective PCI procedures and on the descriptive statistics of Table 7. Table 7 illustrates that there is a substantial difference in distribution of case-mix variables between the acute and elective PCIs, in particular with respect to the variables *'diabetes'* and *'diagnosis leading to initial PCI'* (Table 7). For this reason, an additional dummy variable was created to address this difference. However, only the combination of an elective PCI (i.e. any of the elective PCIs) and diabetes improved the explained variance of the model, any dummy variable of the categorical variable *'diagnosis leading to initial PCI'* did not.

Table 11. Linear regression model to determine the tariff of the bundle

Variable	Type of value	*B*	Std Err *B*	β	p-value
Constant	-	7325.19	250.80	0.00	<.0001
Age	*continuous*	-15.17	3.70	-0.08	<.0001
Female	*dichotomous*	46.60	91.89	0.01	0.6121
Acute PCI*	*dichotomous*	2396.86	134.83	0.55	<.0001
Elective PCI, chronic total occlusion*	*dichotomous*	1301.54	177.85	0.15	<.0001
Elective PCI, multiple arteries or LMA*	*dichotomous*	1206.62	125.67	0.20	<.0001
Elective PCI, corornary graft*	*dichotomous*	1504.51	279.33	0.10	<.0001
STEMI*	*dichotomous*	969.13	138.84	0.20	<.0001
NSTEMI*	*dichotomous*	445.51	118.48	0.08	0.0002
Diabetes	*dichotomous*	-325.95	181.90	-0.06	0.0733
Elective PCI & diabetes**	*dichotomous*	364.21	217.90	0.06	0.0948
Kidney failure	*dichotomous*	918.17	306.29	0.06	0.0028
Initial PCI in academic hospital	*dichotomous*	-322.02	91.36	-0.07	0.0004

*Outcome variable = total claimed tariff (€); n = 1683; R^2= 0.4019; F value = 93.51 (p<.001); Durbin-Watson Test = 1.944; B = coefficient (in €); Std Err B = standard error of coefficient; β = standardized value of B; p-value = test whether predictor value statistically significant differs from 0; dichotomous: 1 = yes, 0 = no; * = categorical variable computed into dummy variable (categorical variable: 'initial category of initial PCI' , reference: 'PCI of single artery'; categorical variable: 'diagnosis leading to initial PCI', reference: 'other diagnosis'); ** = computed variable (any elective PCI in combination with diabetes); assumptions = no perfect multicollinearity (tolerance level > 0.2), homoscedasticity, normally distributed errors, independence of outcome value, linearity of outcome variable*

The linear regression model has a R^2 of 0.4019 and a F-value of 93.51 (p<.001). All of the assumptions for performing a linear regression have been met. The model indicates that age has a relatively small impact on the tariff for a 6-month period, whereas gender is non-significant (Table 11). Nevertheless, they were included in the final model since they did contribute to the explained variance (i.e. R^2) and are of important clinical relevance. Age also has a negative association with the total tariffs claimed, together with the variables *´Initial PCI in academic hospital'* and *'diabetes'*. However, for a patient with diabetes who is treated with an elective PCI, the net increase of the bundle tariff is €38.26 (=364.21-325.95), since the variable *'Elective PCI & diabetes'* was added to the model. The initial PCI category contributes substantially to the model. Compared to the reference variable, *'Elective PCI of a single artery'*, the tariff increases with €2396.86, €1301.54, €1206.62 or €1504.51 when an acute PCI, a PCI for a chronic total occlusion, a PCI of multiple arteries (or the left main artery) or a PCI of a coronary graft is performed, respectively.

5. Defining the bonus tariff (hospital specific)

The mean performance of the outcome variables of all hospitals combined *(n=31)* are presented in the overview of the Menzis claims data (Table 6). By using all the patients in the Menzis claims dataset (*n*=2135), a predictive model for each of the quality outcome variables was created (Table 12). As stated in the Methods section, all case-mix variables were included due to their clinical importance and resemblance to the case-mix adjustment used by MeetbaarBeter. In line with the patient specific bundle tariff, categorical variables were computed into dummy variables using the same reference variables. No extra variables were computed.

Except for the outcome variable *'Ischemic stroke or TIA'*, all models have a *p*-value for the likelihood ratio of <0.01. The outcome variable *'Ischemic stroke or TIA'* did not reach this level due to low number of events, only 0,56% of the 2135 patients (Table 6), which resulted in a quasi-complete separation error in the statistical software and high standard errors. Only in the models of *'Extra PCI'* and *'CABG'* a non-linearity of the logit for the continuous variable *'Age'* in relation to the outcome variable was found. All other assumptions for logistic regression were met.

Table 12. Logistic regression model for bonus tariff, with case-mix predictor variables

		Mortality		*ICU admission*		*Ischemic stroke †*		*Extra PCI ‡*		*CABG ‡*	
Variable	**Type of value**	*B*	Std Err *B*	*B*	Std Err *B*	*B*	Std Err *B*	*B*	Std Err *B*	*B*	Std Err *B*
Constant	-	-8.38 *	0.86	-5.13 *	0.70	-9.17 *	1.99	-1.66 *	0.39	-4.64 *	0.72
Age	*continuous*	0.07 *	0.01	0.00	0.01	0.04	0.03	-0.01 *	0.01	0.01	0.01
Female	*dichotomous*	-0.24	0.27	0.04	0.24	0.74	0.60	0.10	0.14	-0.59 *	0.30
Acute PCI[i]	*dichotomous*	0.50	0.38	1.76 *	0.44	0.42	1.10	0.18	0.20	0.25	0.38
Elective PCI, chronic total occlusion[i]	*dichotomous*	-1.45	1.04	0.14	0.80	0.89	1.24	0.14	0.30	0.87	0.47
Elective PCI, multiple arteries or LMA[i]	*dichotomous*	0.15	0.40	0.53	0.55	-11.12	272.20	0.29	0.22	-0.29	0.52
Elective PCI, corornary graft[i]	*dichotomous*	0.20	0.78	-12.40	699.20	-11.32	687.50	0.80	0.42	-13.60	810.90
STEMI[i]	*dichotomous*	0.36	0.37	0.53	0.34	1.12	1.07	0.48 *	0.21	0.98 *	0.39
NSTEMI[i]	*dichotomous*	-0.44	0.41	0.01	0.38	-0.46	1.27	0.14	0.19	0.65	0.36
Diabetes	*dichotomous*	0.05	0.29	0.06	0.29	0.46	0.70	-0.02	0.17	-0.06	0.32
Kidney failure	*dichotomous*	0.05	0.75	1.39 *	0.54	-11.47	589.50	0.89 *	0.37	-13.80	795.50
Initial PCI in academic hospital	*dichotomous*	0.47	0.24	0.89 *	0.22	-0.14	0.68	0.53 *	0.13	0.30	0.24
Model properties											
C-statistic		0.74		0.76		0.82		0.61		0.69	
Likelihood ratio (p-value)^		<.0001		<.0001		0.152		<.0001		0.0003	

*n = 2135; [i] = categorical variable computed into dummy variable (categorical variable: 'initial category of initial PCI' , reference: 'PCI of single artery'; categorical variable: 'diagnosis leading to initial PCI', reference: 'other diagnosis'); ^ = the likelihood ratio chi-square (p-value represents prediction compared to an intercept only model); * = p-value <0.05; † = Small number of events (i.e. stroke), resulting in quasi-complete separation problems; ‡ = no linearity of logit for predictor variable 'age'; Mortality = probability (p) of mortality within 6 months after initial PCI, all causes; ICU admission = p of ICU admission within three days after initial PCI; Ischemic stroke = p of ischemic stroke within seven days after initial PCI; Extra PCI = p of extra PCI within six months after initial PCI; Extra CABG = p of CABG within six months after initial PCI*

Table 12 shows the results of the logistic regressions of each of the outcome variables. It can be seen that the variable *'Age´* has a positive relationship with mortality but a small impact on other outcomes. In other words, when a hospital treats many high aged patients, the predictive value of the mortality rate will be higher. The model for ICU-admission shows that when a patient who has an acute PCI, is being treated in an academic hospital or has a diagnosis of kidney failure, she or he has a substantially higher chance of being admitted to the ICU than other case-mix variables.

By using the case-mix of a hospital, a predictive value of performance for each outcome variable could be calculated. Table 13 shows the predictive and actual values of performance of two randomly selected anonymous hospitals. The hospital specific predictive values are based on the average of probability of each of the patients treated within that hospital. For example, for each of the patients treated within Hospital A, a probability in *'Mortality within 6-months'* was predicted, based on the case-mix variables of each of these patients. Of all of these probabilities, the mean was calculated, resulting in the predicted mortality rate specifically for Hospital A. This relative difference is defined as the predicted performance minus the actual performance, the results of which is divided by the predicted performance, see Table 13. When the performance of a hospital on an outcome variable was

better (i.e. a lower number of events), the difference was reported as a positive difference. When the performance was less than predicted (i.e. a higher number of events), then the relative difference was negative.

Table 13. Performance of two hospitals.

	Hospital A			Hospital B		
Variable	*predicted vs*	actual	relative difference	*predicted vs*	actual	relative difference
Mortality *(within 6 months, all causes) (%)*	3.53%	4.81%	-36.23%	3.37%	0.88%	280.85%
ICU admission *(%)*	3.48%	3.66%	-5.33%	3.24%	6.19%	-91.21%
Ischemic stroke or TIA *(%)*	0.63%	1.14%	-80.32%	0.64%	0.00%	MAX*
Extra PCIs *(per patient)(%)*	11.75%	7.32%	60.44%	11.22%	7.96%	40.82%
CABGs *(per patient)(%)*	3.32%	1.83%	81.28%	3.34%	9.73%	-191.53%

*n = total amount of patients who received an PCI at the specific hospital; performance = relative increase or decrease (e.g. 100% is a performance twice the predicted value); *MAX = no relative difference possible, maximum performance (i.e. predicted performance cannot be divided by 0); hospitals are selected randomly*

The final step of defining the bonus tariff (Figure 2) involves the setting of the P4P-fraction to include in the bundle. Van Herck et al. (2011) recommend in their paper that, to induce an effect on provider behavior, a percentage between 5-10% should be used.[48] Also, in a review about the state of value-based programs in cardiovascular medicine, Chee et al (2016) mention that a typical incentive for P4P is less than 5% of total provider income.[68] Both Chee et al (2016) and Van Herck et al (2011) do discuss that the size of the incentive and the impact of this percentage differs substantiality between programs. In addition, little evidence is available on what the size of the incentive should be.[48,68] In our current model, the total amount of bonus tariff per bundle was set on 5%. In other words, the maximum bonus or penalty is 5% of the tariff calculated in the previous phase.

The maximum bonus of 5% is then equally divided into each of the five outcome variables. This means that when a certain relative difference threshold is reached, a maximum of 1% of the tariff can either be earned or lost per outcome variable. In our model a relative difference threshold of 50% was used for both the bonus and penalty. An example is given in the next section.

An example of the model in practice

The following hypothetical example describes the calculation of a bundle tariff for PCI.

Patient X, male, 63 years of age, diabetic since 2011, no kidney failure. Mr. X experiences sudden chest pain and is sent to the Emergency Department of Hospital A. Hospital A is a small rural hospital (i.e. not academic). Here, after an ECG, a ST-elevated myocardial infarction (STEMI) is diagnosed and an acute percutaneous coronary intervention (PCI) is needed. See

Table 14 for the calculation of the total tariff of the bundle.

Table 14. Example of a calculation of a bundled payment for PCI

Bundle tariff (patient specific)			
Constant		€	7,325.19
Age	(-15.17 x 63 =)	€	-955.57
Acute PCI		€	2,396.86
STEMI		€	969.13
Diabetes		€	-325.95
Total sum		€	9,409.67

Bonus tariff (hospital specific)			
Maximum bonus (5%)	(€ 9,409.67 x 5% =)	€	470.48
per outcome variable	(€ 470.48 / 5 =)	€	94.10

Performance of Hospital A

variable	**predicted**	**vs actual**	**relative difference**		**tariff per variable***
Mortality	3.53%	4.81%	-36.23%	€	-
ICU	3.48%	3.66%	-5.33%	€	-
Stroke	0.63%	1.14%	-80.32%	€	-94.10
PCI	11.75%	7.32%	60.44%	€	94.10
CABG	3.32%	1.83%	81.28%	€	94.10
Total sum				€	94.10

Total tariff of the bundle
(for treating patient X)

€ 9,409.67 + € 94.10 = € 9,503.77

**tariff per variable is maximum tariff per variable when a relative difference of 50% or minus 50% is reached; a bonus is being applied when the relative difference is more than 50%; a penalty is being applied when the relative difference is less than minus 50%; relative difference = relative increase or decrease (e.g. 100% is a performance twice the predicted value); see previous tables for explanation of abbreviations and other details on the variables .*

Discussion

This report investigated the concept of bundled payments and it created a bundled payment model specifically for percutaneous intervention (PCI) in the Dutch health care system. This model was designed using a literature search, expert opinion and claims data from a health insurer. When examining all of the different phases of the bundle design, including the linear and logistic models used, it can be concluded that each phase in the design requires many choices and/or agreements which depend on preferences of providers and payers. It is for this reason that a multi-disciplinary team is needed to create an adequate bundled payment scheme.[41,42] Each phase of the design is discussed below in separate paragraphs. Each paragraph ends with the choices and agreements specifically for that phase. These agreements are then the foundation of a bundled payment contract between provider and payer.

1. Defining the patient

For our model the patient was defined according to the definition used by MeetbaarBeter. Yet, we could have chosen to make several different bundles. For instance, one for an acute PCI and one for an elective PCI, either with or without a certain diagnosis (e.g. STEMI). However, if we make too many bundles we are moving back in the direction of paying separately for different DRGs. It would also have been possible to exclude certain patients beforehand, as was done in many of the previous programs (Table 5). The only exclusion used in this model was the exclusion of patients who underwent a PCI in the 6-months before the PCI that was defined as the initial PCI. This ensures that a new bundle cannot be started while a previous PCI was still within its bundle time-frame.

2. Defining the time-frame

The choice of the time-frame is arbitrary, as is the chosen 6-month period used in this model. A shorter period could have been chosen because most costs are made within 30-days after the initial PCI and a shorter period can prevent underuse since providers will not be incentivized to delay care until after a 6-month period (i.e. outside the bundle time-frame). However, in our model a 6-month period was chosen because of the importance to incentivize providers to focus on preventive care. A good example for this is a study by Arnold et al (2015) in which 24% of the 2573 patients questioned still reported angina six months after the initial PCI.[69] Also, Fong et al (2011) describe a pathway for PCI suitable for bundled payments and also address the importance for a longer period. They argue that the intensity of '*Behavioral-Change Interventions*' after PCI increases and maximizes between 90 days and 180 days after discharge.[63] A time-frame should, in any case, be treatment- or diagnosis-specific since follow-up care and the importance of preventive measures differs between treatments and diagnoses. For elective PCIs, for instance, one could also argue in favor of including services which are provided in the

work-up leading to the PCI, such as a diagnostic coronary angiography, as was done in some of the previous programs (Table 5).

3. Defining the content

In our model all cardiac and cardiothoracic surgery care, related and unrelated to the initial PCI, was included into the bundle. This choice has its advantages. First, it can be very difficult to determine which of the care provided is actually associated with the initial PCI or diagnosis. Second, it is impossible to game the process since no one defines or registers the care that is associated to the initial PCI. Third, it prevents an increase in administrative work. On the other hand, the choice of including all the care comes with disadvantages as well, such as providers being incentivized to delay necessary care until after the bundle time-frame. Also, providers might not be inclined to join the program since it inhibits them from giving additional services which are unrelated to the initial PCI. To address these issues, a stop-loss agreement was defined so that expensive unrelated services are excluded. However, the less expensive and also unrelated services are still taken into account since they are part of the calculation of the tariff (see phase 4). Nonetheless, this still remains an important choice within the design of the bundle and so it is also an option to create a list of specific services (or DRGs) which are clearly unrelated to the initial PCI and will not be included into the bundle (therefore not included in the calculation of the bundle tariff).

4. Defining the bundle tariff (patient specific)

We have chosen to set a bundled tariff that is calculated separately for each patient and is thus not based on the historic case mix of a hospital. This was done to make the model a prospective payment form. If the case-mix of a hospital was used to calculate a prospective tariff, providers would have an incentive for adverse selection since the payment is based on a different case-mix (e.g. from previous years). In other words, calculating a tariff that is adjusted for a hospital specific case-mix can only be done retrospectively. Before the linear model was made, outliers were defined as more than 120% of the mean of the total tariff of DRGs claimed. This percentage can be seen as relatively low. For example, when an extra acute PCI is needed after an initial PCI which was also acute and in both cases hospital admission was needed, the total tariff of both DRGs could reach €14,899.10.[47] This means that although the second PCI could be due to a complication of the initial PCI, the provider is fully reimbursed (since €14,899.10 > €12,708.23). To some extent, an extra PCI can result in a penalty for outcome and an extra PCI can lead to an increased mean of all the bundles, resulting in a higher stop-loss agreement. The 120% in our case was used to minimize the financial risks for providers. A higher stop-loss agreement, for example of the 95th percentile, can also be agreed upon, as discussed by the American Medical Association™ (AMA).[70] However, a higher stop-loss does mean an increase in the provider's financial risks. It is because of this increase that the AMA describes the possibility for

providers to lower the stop-loss when they pay a monthly premium, similar to an insurance agreement. Once the outlier category has been established, the linear prediction model can be set. Our prediction model was able to account for 40% of the variation of the tariff (R^2=0.4). It is possible that this R^2 increases when more, patient specific, case-mix variables are included. However, it cannot be determined whether this R^2 is sufficient, since there have not been other models that predict costs for a 6-month period after a PCI treatment. Also, the R^2 can be of less importance when providers and payers are able to come to an agreement on the model and the use of the case-mix variables. Lastly, predicting costs, or spending, in health care is very difficult in general, as can be seen in the risk-adjusted model used by the Dutch government to compensate health insurers for accepting high-risk patients as customers.[71]

All of the variables used in our model contributed to the explained variance and many contributions were statistically significant (*p*-value <0.05). Among those variables is the *´Initial PCI category'*. It was expected that this variable would contribute substantially since current DRGs, on which the model was based, do already distinguish between type of PCI and are now simply put in one model simultaneously. To our surprise, the variables *'Age'* and *'Initial PCI in academic hospital'* both had a negative relationship with the predicted tariff. For *'Age'* this, minimal negative contribution, could be explained by the removal of the outliers since a positive relation was found in the descriptive statistics of all the patients (*n*=2135; results not shown). In addition, it is possible that the negative relationship in the model is because patients receiving an acute PCI tend to be younger, compared to an elective PCI (63.06±12.15 vs 66.26±10.47). The negative relationship with the *'Initial PCI in academic hospital'* variable could be explained by the use of the average DRG-tariffs. DRG-tariffs for academic hospitals are, on average, higher than DRG-tariffs for non-academic hospitals since these larger academic hospitals have more costs for tertiary and specialist care.[72] The final tariff agreed between provider and payer could compensate for this difference. The results, however, do show that academic hospitals do not provide more services and/or claim more expensive DRGs than non-academic hospitals.

5. Defining the bonus tariff (hospital specific)

For each of the quality indicators a logistic model was made to predict the probability of an event for the hospital's specific case-mix. The importance of each of the predictor variables differs substantially between the different outcomes. The *c*-statistic also differs between models, ranging from 0.61 to 0.82. These values are lower than the *c*-statistic MeetbaarBeter was able to establish in 2016. For instance, by using more predictor variables and the data of 16 heart centers, in a period from 2011-2015, MeetbaarBeter was able to create a predictive model for mortality with a *c*-statistic of 0.89.[45] So it might be advisable to include more patients over a longer period of time and more predictor variables into the regression so that the *c*-statistic can be increased. Especially when payment is associated with the model. However, as with the R^2 in the linear regression of phase 4, it is of more

importance that providers and payers are able to come to an agreement on the choice of case-mix and outcome variables, and there effect on payment (in our case 5%). Aside from the logistic regression itself, it is also important to determine when a provider is performing better than the predicted value. In our model, a relative difference from the predictive value was calculated but an absolute difference can also be used to define a better or worse performance outcome than the benchmark. In addition, it is important to define when a certain level of performance is reached. In our design, a relative difference of more than 50% or less than minus 50% was chosen as a threshold for a bonus or a penalty respectively. However, this threshold can also be different for each of the outcome variables. For example, a relative difference of 25% in extra PCIs might be considered more important than a relative difference of 25% in ICU-admittance (or vice versa). Also, apart from this threshold, it can be agreed upon which outcome variable should be a larger part of the P4P fraction. In the design of our model the P4P-fraction was equally divided into each of the outcome variables (i.e. 1% per variable), but providers and payers might agree to give, for example, 2% to mortality and 3% to the other outcomes because they agree that mortality can be considered as more important.

Limitations

Available evidence in literature

The literature that is available on bundled payment specifically on PCI is limited and most of the studies and experiences that were found are from the US. From the limited amount of programs present, only a few had good accessible evaluations. Because of this, elements from the theoretical framework were customized, so that they would be applicable to a PCI specific bundle. However, together with total hip or knee replacement and coronary bypass surgery, PCI is among the few treatments on which literature on bundled payments is available at all.[24,25]

Available data for analysis

The data used for this report has its limitations. First, health insurers in the Netherlands have different market shares throughout different regions of the country.[73] Because data of only one health insurer was used, this can possibly create a selection bias since patients from only specific regions of the country were used. Nevertheless, the dataset still consisted of a relatively large sample size, which is useful for creating an adequate prediction model.[74] Second, by using data from a health insurer, only claims data was available. This, as mentioned in the theoretical framework, can be undesirable since the tariff of a bundle is preferably based on actual costs and not on claims data.[31,32] However, this model is designed for the process of substituting DRGs (i.e. the current situation) by bundled payments. This means that the total amount spend on certain DRGs is similar to the predicted amount spend using bundles. So although it does not represent actual costs, it does represent the amount spend by health insurers for this certain type of care. Third, only a limited set of predictor variables

were available to calculate the case-mix corrected tariff. For example, Bradley et al (2015), published in *Circulation,* describe the variation in costs 30 days after PCI.[75] For their risk-standardization of costs, 24 different variables were used (including body mass index (BMI), cardiogenic shock before PCI and the amount of hospital beds). Preferably all the variables registered by MeetbaarBeter, which are fairly similar to Bradley et al (2015), are used to create a prediction model (see appendix C).[44] By linking the patient characteristics from MeetbaarBeter to the claims data of a health insurer, a more accurate model can be created that contains a full set of case-mix variables which are composed and approved by physicians. Although this report does not contain the full set, it can be used as template for future designs where more (or different) variables are being added.

Fairness of the program

Despite our best efforts, the question remains whether the currently proposed model is fair. This question is related to the question whether the model sufficiently accounts for the heterogeneity of patients. Even though a model is well designed and providers reach consensus for adequate case-mix correction, the model cannot perfectly cover all the patient characteristics that could influence the tariff. Because of this, some hospitals are unable to increase their efficiency or might score less on quality due to patient characteristics that are not covered by the model. To solve this problem, bundles can be based on a model that is estimated using hospital specific data, rather than a model that is based on nationwide data. When a nationwide tariff is used in a pilot program, it is possible that providers experience unexpected budget constraints since they might receive less than they are used to, this can cause providers to decline participation. Eventually, a nationwide tariff could induce competition between providers and could therefore be beneficial for patients. The fairness of the model is also of importance for the bonus tariff when this tariff is based on a benchmark that is based on peers. For example, providers who do not perform well overall might still have improved their quality of care compared to a year earlier. These providers then do not receive a bonus that they could have used for improving the quality of care even further.

Quality assessment

In the end the goal of bundled payments is reducing costs while still improving the quality of care. This model, however, does not contain variables which are patient reported. MeetbaarBeter has a wider range of outcome variables than the variables used for this model, but patient reported outcome measures (PROMs) and patient reported experience measures (PREMs) are not yet used (except for quality of life which is being collected but not published). On the other hand, according to Greenhalgh et al (2017), it is questionable whether PROMs, for example, should be linked to the payment of performance.[76] Due to credibility of these outcome measures for the definition of good patient care and the possibility of gaming the process by selectively including certain patients.

Contractual agreements

According to the incentives and challenges listed in the theoretical framework section and elements mentioned in the previous experience section, there are still some elements of a bundled payment program which are not addressed in the model designed for this report. When a contract is established between provider and payer, the following items should also be agreed upon or taken into consideration:

- A gain-sharing or loss-sharing agreement between provider and payer, based on the total budget spent due to the implementation of a bundled payment program.[51,52,59]
- Agreements about patients who switch provider or insurer within the time-frame of a bundle.[27]
- Agreements for small (rural) hospitals or providers which only have a small market share for a specific insurer (e.g. a volume threshold).[15,40]
- Agreements on 'gaming' the process of patient characteristics registration and/or registration of quality outcome variables.[36]
- Agreements on a possible increase in volume (i.e. the amount of bundles).[27,33]
- Agreements on a possible increase of DRGs claimed outside the bundle or an increase in the amount of patients whose costs exceed the stop-loss agreement.[27]

Conclusion

The increase of spending in the health care sector, and specifically specialist care, is an important issue in many countries, the Netherlands being no different. Alternative forms of payments are being implemented to reduce costs and improve quality. Among those new forms of payment is bundled payments. Bundled payment can be defined as receiving a fixed amount of payment per patient having a certain illness or per treatment episode. By using the concept of bundled payments and the experiences of previous programs this report designed a bundled payment which can be used by providers and payers to make contractual agreements on paying for health care. However, considering the points of discussion and the room for improvement identified in this report, it can best be used as a template for designing and further optimizing bundled payment programs. The model in this report was specifically designed for percutaneous coronary intervention, but the phases of defining the patient (1), the time-frame (2), the content (3), the tariff (4) and the bonus tariff (5) are applicable for multiple treatments and diagnoses. Our model is only ready for implementation when providers and payers have made important choices and agreements about the details of every phase. More research is not necessarily needed on the concept of bundled payment but more research is needed on the details of the implementation.

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Appendix A

Abbreviations

Abbreviation	Description
ACA	Affordable Care Act
ACO	Accountable care organizations
ACS	Acute coronary syndrome
AHA	American Hospital Association
AMA	American Medical Association™
AMC	Academic Medical Centre Amsterdam
AMI	Acute myocardial infarction
BPCI	Bundled Payments for Care Improvement™
CABG	Coronary artery bypass grafting / Coronary artery bypass graft surgery
CMS	Centers for Medicare & Medicaid®
DRG	Diagnosis-related-group
ECG	Electrocardiography
FFR	Fractional Flow Reserve
FFS	Fee-for-service
GDP	Gross Domestic Product
GP	General practitioner
HCA	Health care activity
HEPL	Health Economics, Policy and Law
ICD	Implantable cardioverter defibrillator
ICU	Intensive care unit
IVUS	IntraVascular UltraSound
LMA	Left main artery
MD	Medical doctor
MeetbaarBeter	Stichting Meetbaar Beter®
Menzis	Menzis Zorgverzekeraar N.V.®
NHS	National Health Service (UK)
NSTEMI	Non- ST-elevated myocardial infarction
OCT	Optical Coherence Tomography
P4P	Pay-for-performance
PAC	Potentially Avoidable Complication
PCI	Percutaneous coronary intervention
PREM	Patient reported experience measures
PROM	Patient reported outcome measures
PROMETHEUS®	ProviderPayment Reform for Outcomes, Margins, Evidence, Transparency, Hassle-reduction, Excellence, Understandability and Sustainability
SAS®	Statistical Analysis System
STEMI	ST-elevated myocardial infarction
TAVI	Transcatheter aortic valve implementation
TIA	Transient ischemic attack
TVR	Target vessel revascularization
UK	United Kingdom
US	United States of America

Appendix B

For all the information regarding the DRG-system in the Netherlands, the website www.nza.nl can be consulted (Dutch and English).

DRG-data in the Netherlands

Most payments of secondary care providers in the Netherlands are done through DRG's. There are currently around 4500 DRG's each representing a combination of services (diagnostics and treatments). For a PCI, for example, there are currently 5 different subgroups (**Table B.1**).

A DRG consists of multiple health care services. Providers are required to register each service (or Health Care Activity, HCA) that a patient consumes or the provider uses. This includes for example, the treatment itself, each hospitalization day, every scan and ECG* performed as well as every laboratorial test. The combination of all of these HCAs creates a unique health care product code. This code is then linked to a specific DRG-code which in turn is linked to a certain tariff (**Table B.1**). Thus, the registration of each HCA determines which tariff is used for reimbursement. In addition, each HCA has to be registered with a diagnose code, so that the HCA is linked to a specific diagnosis.

In the Netherlands there are two different segments in determining tariffs: the A-segment (DRG-codes starting with 14) and the B-segment (DRG-codes starting with 15). The A-segment codes have a maximum tariff determined by the Dutch Health Authority (NZa), which, in most cases, includes acute medical treatments. The B-segment tariffs are to be negotiated between payer and provider.

Table B.1. DRG's for PCI as determined by the Dutch Health Authority (NZa)[i]

DRG-code:	Name	Description	Hospitalization Days ?	Maximum Tariff
14D685	PCI type 1	Removing stenosis, one branch	No	€ 3,183.10
14D684	PCI type 1	Removing stenosis, one branch	Yes	€ 5,692.10
14D683	PCI type 2	Removing stenosis, multiple branches or main stem	No	€ 3,278.04
14D682	PCI type 2	Removing stenosis, multiple branches or main stem	Yes	€ 6,099.34
14D681	PCI type 3	*Removing stenosis using Fractional flow reserve (FFR) and or* IntraVascular UltraSound (IVUS)	No	€ 5,278.81
14D680	PCI type 3	*Removing stenosis using Fractional flow reserve (FFR) and or* IntraVascular UltraSound (IVUS)	Yes	€ 7,406.59
14D679	PCI type 4	Acute PCI (e.g. ST-elevation myocardial infarction)	No	€ 4,495.02
14D678	PCI type 4	Acute PCI	Yes	€ 7,449.55
14D677	PCI type 5	Extensive PCI treatment	No	€ 15,847.38
14D676	PCI type 5	Extensive PCI treatment	Yes	€ 17,350.95

Also follow-up treatments and possible complications consist of DRG's. For instance there are DRG-codes for 'follow-up after an acute coronary syndrome'. DRG-code 15B359, as an example, consists

* Electrocardiography

of more than 28 hospitalization days after an acute myocardial infarction whereas DRG-code 15B360 consists of 6 till 28 hospitalization days.

It is important to mention that the tariffs do not represent actual costs. In the A-segment the maximum tariffs are set by the NZa, but, since they are not hospital specific, these tariffs might not represent actual cost prices of a specific hospital. In addition, purchase contracts between providers and HIC usually contain budgets instead of price agreements on DRG's. Therefore, the B-segment tariffs are usually derived from the total budget (which includes all of the care given by the provider) and so they do not represent actual cost prices as well. It is for this reason that the tariffs in the B-segment can differ substantially between hospitals. Although the deviation of tariffs from actual costs is acknowledged, it goes beyond the scope of this master thesis to do a detailed costing study to determine the actual costs.

References appendix B

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Appendix C

Overview of variables

Table C.1. gives an overview of the variables published by MeetbaarBeter and the variables from Menzis claims data which were used for this report

Variables used by MeetbaarBeter are derived from their reports.[i,ii]

Table C.1. Overview variables MeetbaarBeter and Menzis claims data;

Variable	MeetbaarBeter	*Type of value*	Menzis	*Type of value*	*Remarks*
Case-mix					
Age	✓	in years	✓	in years	
Gender	✓	male / female	✓	male / female	
Kidney failure	✓	4 stages	✓	yes / no	6 months prior to PCI
Diabetes	✓	yes / no	✓	yes / no	6 months prior to PCI
Indication initial PCI	✓	elective, STEMI or NSTEMI	✓	acute / elective and STEMI / NSTEMI / other	
Treatment of multiple arteries	✓	yes / no	✓	yes / no	
Chronic total occlusion	✓	yes / no	✓	yes / no	
Cardiogenic shock	✓	yes / no	✗		
CABG in medical history	✓	yes / no	✗		
Myocardial in infarction history	✓	yes / no	✗		
Left ventricle function	✓	3 stages	✗		
Resuscitation before PCI	✓	yes / no	✗		
ICU admission to PCI	✗		✓	yes / no	6 months prior to PCI
Outcome					
Mortality	✓	within 30days and 1 year	✓	yes / no	within 6 months after PCI
Urgent CABG (within 24 hours after PCI)	✓	yes / no	✓	yes / no	within 6 months after PCI
Myocardial infarction (within 30 days)	✓	yes / no	+/-	yes / no	extra PCI treatment within 6 months after initial PCI
Target vessel revascularization (TVR) (within 1 year)	✓	yes / no			
Cerebral infarction or transient ischemic attack	✗		✓	yes / no	within 2 weeks after PCI
Admittance to ICU	✗		✓	in days	within 3 days after PCI

Additional remarks include any difference between the variables.

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Appendix D

Previous experiences of bundled payments for percutaneous coronary intervention (PCI)

Each program that was found during the literature search (including the report by The Clinical Episode Payment Work Group[i] and the review by Hussey et al[ii]) will be described by its contents and, if available, evaluation. In addition, the examples are used in the results section when the bundle for PCI is further defined and lessons from the other programs are being used. The following programs, primarily focusing on services of specialist care, are being addressed:

Table D.1. Overview of programs of bundled payments for PCI

Year of introduction	Program
2005	Geisinger Health System (GHS) PCI ProvenCare Initiative
2006	PROMETHEUS/ Health Care Improvement Initiative Institute
2013	Centers for Medicare & Medicaid (CMS): Bundled Payments for Care Improvement (BPCI)
2014	Tennessee Health Care Improvement Innovation Initiative
2015	Arkansas Health Care Payment Improvement Initiative
2017 (planned)	Centers for Medicare & Medicaid (CMS): Episode Payment Models

The programs will be discussed using the following points:

- Content of the bundle (incl. initial procedure and complications)
- Time frame of the bundle
- Bundle tariff
- Use of risk-adjustment
- Use of quality metrics
- Results / evaluation of the program

ProvenCare Initiative

ProvenCare by Geisininger Health System (GHS) was initiated in 2005 for coronary artery bypass graft surgery (CABG) and shortly after they developed a program for different conditions/treatments including PCI.[iii]

Content: The content included elective PCI's and follow-up care that was designed by cardiologists, best practices and guidelines (evidence) on cardiac care. It included pre-operative evaluation, all hospital and professional fees, routine post-discharge care, and management of related complications occurring within 90-days of procedure.**Fout! Bladwijzer niet gedefinieerd.**

Time frame: A total of 90-days post-discharge.

Bundle tariff: Prospective payment and price was based on historical data from the departments related to the episode and directly linked to quality measurements.

Use of risk-adjustment: Use of limited exclusion criteria but no separate risk-adjustment payment; quality metrics are, however, risk stratified for the P4P model.

Use of quality metrics: The program addressed 40 quality indicators (process elements). Including, contrast-induced nefropathy, increase of heart enzymes after procedure (indicating AMI), discharge medication.[iii]

Results: A decrease in total length of stay (LOS) was registered from 2.86 days to 2.50 and post-procedural from 2.27 to 1.69 and use of PCI via the radial artery (preferred access) increased from 34% to 80%.

PROMETHEUS

The Prometheus Analytics model was designed by the Health Care Incentives Improvement Institute (HCI3).[iv] Prometheus episode based payment uses 'evidence-informed case rate' (ECR). An ECR contains all covered services linked to a condition or treatment and to a specific patient.[v]

Content: The ECR for PCI includes elective and emergent (acute) PCI treatments. A distinction is made for necessary care (typical costs) and potentially avoidable complications (PACs).

Time frame: The time frame is 60-days prior to admission and 180-days post-discharge for elective PCI[vi] and 30-days after an acute myocardial infarction.[vii]

Bundle tariff: The tariff for an ECR is based on claims data and claims data is marked with typical care or complication. For each episode providers receive patient-specific budgets which are based on expected cost of typical care, expected cost of complications, allowance for underuse, PAC's allowance and an additional margin. Payment is done prospectively but payment for risk-adjustment is done retrospectively.[i]

Use of risk-adjustment: For the allowance of PACs, severity adjustment is applied. This includes: comorbidities, patient-demographics, historic risk factors and clinical severity markers. Exclusions are present such as: age <18 and >64 years, patients with cancer, HIV or end-stage renal disease. Stop-loss can be added.

Use of quality metrics: The costs of PACs are used as the primary measure for quality; the higher the costs of PACs, the lower the assumed quality. Additional P4P can be added if agreed upon between insurer and provider.

Results: Hussey et al concluded in 2011 that the implementation of model, not specifically for PCI treatment, experienced major challenges because of the complexity of the model.[viii] No specific evaluation for PCI treatments were found.

Bundled Payments for Care Improvement (BPCI by CMS)

The BPCI program is designed by the Center for Medicare and Medicaid Innovation (CMS) in 2011 as part of the introduction of the ACA.[ix] The BPCI program started in 2013 and consists of four models (see table D.2) and applies to episodes of many different diseases and treatments. Providers are able to join of leave the program voluntarily and were free to choose any model. They could then choose to join for any of the 48 treatment episodes. Since model four corresponds to the design for this thesis, model four will be discussed.

Table D.2. Different models of the BPCI program[ix]

Bundle includes → / Model number ↓	Acute care	Post-acute care in hospital	Post-acute care outside of hospital	Prospective / Retrospective payment
Model no. 1	Yes	No	No	Prospective
Model no. 2	Yes	Yes	Yes	Retrospective
Model no. 3	No	Yes	Yes	Retrospective
Model no. 4	Yes	Yes	No	Prospective

Content: Episodes include AMI or a PCI treatment and all services within the hospital linked to the initial treatment (e.g. readmissions). Each episode includes a gathering of multiple DRGs.[x] It is defined which DRG initiates (or triggers) the bundle. If a readmission, related to the treatment, occurs in a different hospital, the provider is paid not through the bundle but via traditional FFS.

Time frame: The time frame is 30-days post-discharge.

Bundle tariff: Costs are based on three years of historical claims data and separate payments for medical education, disproportionate share hospital and capital payments are provided.

Use of risk-adjustment: Excluded, from any Model 4 Episode, are patients with End Stage Renal Disease. CMS also provides additional payments for outliers (not further defined). No other form of risk-adjustment is used.

Use of quality metrics: Participants are required to let CMS record quality metrics such as patient experience, patient safety, complication rate, mortality and readmission. But this does not have consequences for the bundle tariff.

Results: The Lewin Group (2016) reports that Model 4 was the option with the lowest number of providers (n=20) compared to models 2 and 3(n=110 and n=63 respectively).[xi] Furthermore, 10 out of 20 providers ended their participation before the end of the program. This was mainly because of the amount of data files hospitals received from CMS which delayed payments to their physicians. Of the 20 providers, no provider chose to participate for the episode of AMI and 7 for the PCI episode. Results specifically for PCI are not available. However, it was concluded that participants in Model 4 primarily focused on reducing readmissions to reduce costs. Furthermore they established new relationships with providers that have specific services for post acute care. Though, the participants reported that it was difficult to track those patients who were referred to these providers and at risk for readmissions. As of 1 January 2017 only 5 providers are participating in phase 2 (the risk-bearing period) of the BPCI program of which one participates in the PCI episode.[xii]

The Tennessee Health Care improvement Innovation Initiative

The state of Tennessee together launched this program in 2013, which included payments for episodes of care for PCI as of 2014.[xiii] As of January 2017, the insurance company BlueCross BlueShield of Tennessee incorporated this model as well.[xiv]

Content: The program has 2 episodes; one for non-acute PCI[xv] and another for acute PCI treatment.[xvi] Only costs that are related to the PCI are included. Patient who were partially uninsured or switched provider during the episode are not included.

Time frame: For acute PCI the time frame is 30-day post discharge while for non-acute PCI the time frame starts 90 days before treatment and ends 30 days after.

Bundle tariff: Payment is based on historical claims data that is risk adjusted. Additional payment is done for risk adjustment. Gain- and risk-sharing of 50% is applied.

Use of risk-adjustment: Episodes which deviate significantly from a regular care path for PCI or in the case of incomplete data are excluded. Some examples of other exclusion criteria: patients who are over 64 years of age, necessarily needed a CABG in the acute setting, had a cardiogenic shock, died within the episode period or were admitted to the intensive care are excluded. Risk adjustment is applied in the tariff. When risk factors are identified an '*Episode Risk Score'* is calculated. The included risk factors and their methodology are determined by the individual provider since it is argued that the population and the significance of those risk factors vary across providers. BlueCross does have specified the risk factor for each episode.[xvii]

Use of quality metrics: Payment is not based on quality metrics but payment is only done when certain quality thresholds are reached. Also quality metrics are risk adjusted.

Results: No evaluation reports have been found and although a memo which contains feedback from providers is available, this does not include feedback on PCIs.[xviii]

Arkansas Health Care Payment Improvement Initiative

The state of Arkansas also initiated episode payments for their Medicaid beneficiaries as well as in cooperation with BlueCross BlueShield of Arkansas. In January 2015, BlueCross Arkansas launched its PCI program.[xix]

Content: PCI treatment and all the facility services linked to the initial treatment, including medication.[xx]

Time-frame: 30-day post procedure. If a diagnostic angiogram is performed 30 days prior to the PCI all other care within those 30 days and associated to the PCI is included as well (suggesting that an elective PCI also includes care prior to the intervention).

Bundle tariff: The total bundle tariff is based on claims data and an additional reimbursement is done for complications. Gain- and loss-sharing is applied and dependent on quality metrics. No payment for risk-adjustment is added.

Use of risk-adjustment: Not present as of now. There are exclusions compared to the Tennessee program, such as: 65 years of age and above, acute CABG within one day, outliers in costs (three standard deviations above the average costs), and a list of 55 co-morbidities which are present in claims data within 365 days before procedure.

Use of quality metrics: Quality metrics include adverse outcomes within 30 days after procedure such as: myocardial infarction, stent thrombosis, wound infection and pulmonary embolism.

Results: There is currently no evaluation to present.

Episode Payment Models (by CMS)

The BPCI program by CMS was a voluntarily program but the next program by CMS, also in accordance to the ACA, is the Episode Payment Models program and is mandatory for providers. This program has four episodes which are planned to start as of October 2017. The episodes are CABG, cardiac rehabilitation, surgical hip and femur fracture treatment and acute myocardial infarction (AMI).[xxi] The latter will be included in this analysis.

Content: All services linked to the hospitalization for AMI (which is also initiated by a PCI in acute setting) is included, specialist as well as non-hospital care. [xxii] Defined and unrelated services are excluded (approximately 1200 diagnoses).[xxi]

Time-frame: 90-days post discharge.

Bundle tariff: If a certain standard of quality is not met payments will not be provided. Acute care hospitals are paid the bundle tariff prospectively (target price), based on retrospective claims data and a bonus or penalty may be applied retrospectively for quality based on the performance of a hospital. Additionally, to protect the hospitals from excessive financial risks, there will be a stop-loss and stop-gain limit of 5% in year 1, 2 and 3 and 10% in year 4 and 20% in year 5. Meaning losses or gains by the program are buffered.

Use of risk-adjustment: Small urban regions, with population of less than $50.000, are not eligible for the program. Actual payment is not risk-adjusted, the quality metrics are; meaning that only the payments linked to quality outcome are risk-adjusted. Risk-adjustment includes age, sex and comorbidities.[xxiii]

Use of quality metrics: For the part of payment that depends on quality, the following three indicators are used: 30-day mortality rate (all-cause), excess days in acute hospitalization and patient experience.

Results: The program has not yet been implemented but has already been criticized.[xxiv] Although costs can be saved, since 17% of Medicare Beneficiaries hospitalized for AMI were readmitted within 30 days, Song & Blumentahl (2016) discuss that physicians might not be incentivized to focus on long-term outcomes due to the relatively short 90-day period. Furthermore they address a risk in reduction of PCI treatments in high risk patients due to the absent of proper risk-adjustment.[xxiv]

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