

Evaluating Payment Models for High-Cost Curative Therapies

Single and Multipayer System Perspectives in England and the U.S.





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AUTHORS

Milliman :

Didier Serre, ASA, MSc

Joanne Buckle, FIA

Anne Jackson, FSA, MAAA

Jessica Naber, FSA, MAAA

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The POG members are in alphabetical order:

Ken Avner

Kevin Donnelly

Josh Hammerquist

James Kohan

Robert Lieberthal

Bradley Paulis

Dan Pribe

Christine Tremblay

Xiaoling Zhang

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Note From Authors

High-cost curative therapies have begun to enter the market, and more are expected to follow, particularly in the rare-diseases space. The pipeline for these high-value therapies is growing, but traditional payment for care—where cost is incurred up front at the time of treatment administration—could strain a payer’s annual budget if these therapies launch at record-setting prices. Many of these therapies have the potential to provide an extended duration of clinical benefit from a single-administration or limited treatment duration. In an environment where members can switch insurers, there is a risk that the entity paying for the curative therapy does not realize the expected financial savings linked to the cure.

In this wider context and informed by a survey of the literature and our own experience, we decided, as a research group, to investigate payment mechanisms for high-cost curative therapies. We intend for this research to be a resource to a variety of stakeholders, both within the health care actuarial community and outside of its traditional boundaries. We also believe that the need for designing alternative models should recognize the risks to payers, manufacturers and third-party entities and that it should consider ways to mitigate or share the responsibility of these risks.

Collectively, rare diseases lose their rarity. As more therapies and therapy–indication combinations are approved over time, the aggregate exposure of payers may become more material and may pose financial risks to both smaller and larger payers. As more therapies are approved, the aggregate exposure should increase, and the need for alternative payment models may come into sharper focus.

Executive Summary

High-cost curative therapies, such as gene therapies and CAR-T cell therapies, are being introduced into the U.S. and Europe. These therapies are expected to provide high value to patients, especially for patients diagnosed with rare diseases and patients who have few treatment options.

Current funding mechanisms (i.e., taxes for national health systems and premiums for private health insurers) are structured to cover the expected costs of treating patients. In the case of a one-time high-cost curative therapy, there is a mismatch between the up-front treatment costs and the long-term realization of clinical benefits to patients. The purpose of an alternative payment model may be rooted in one or both of two concerns: (1) a need to mitigate a cash flow strain associated with a single high-cost event, and (2) an improved allocation of expense recognition for the durable therapy over the period of clinical benefits. Additionally, the potential that a payer is unable to recoup most or all potential future financial benefits linked to a high-cost curative therapy is a major risk to a payer funding the therapy. For this reason, it is important that payers, third parties, and manufacturers contemplate ways to mitigate, share, or eliminate the financial risks associated with these therapies.

Alternative payment models for high-cost curative therapies have been discussed in literature, but no systematic review has been performed to support a comparison across a variety of payment models. The purpose of this report is to evaluate alternative payment models that could be instituted in the real world to pay for these high-value and high-cost curative therapies, using a common set of assumptions and evaluation framework. This analysis is from the point of view of the initial payer, the entity paying for the cure. For this study, a curative therapy is defined as a therapy that is administered once and improves a person's clinical state or cures a condition for a sustained period of time.

Several alternative payment models are presented in this research:

- Industry pooling
- Multiyear insurance
- Annuity payments
- Annuity payments with effectiveness guarantee
- Health currency
- Financial bonds
- Financial bonds with effectiveness guarantee

Our focus is on risk-sharing approaches between payers and third-party entities, such as manufacturers, other payers, or financial institutions. Payment models that do not pay the cost of the therapy in an explicit way (e.g., bundled payments or disease capitation) or that share the financial burden with secondary insurers (e.g., reinsurance or stop-loss insurance) were not considered for this study. We acknowledge that these approaches also could be used as alternative payment models.

We rely on England and the U.S. as examples of a single-payer system and a multipayer system, respectively. The focus of this research is not on the quantitative values, and it does not intend to inform pricing of a curative therapy. Rather, the focus is on the extent to which each of the proposed payment models can diversify, mitigate, or eliminate financial risk after the decision to fund a therapy has been made.

Each payment model was evaluated using two rare diseases, hemophilia and cystic fibrosis, as illustrative examples. Both are genetic conditions that have benefited from therapeutic innovation but for which no curative therapies are currently available. For both, however, gene therapies are in the pipeline to treat the disease. The morbidity risk for these diseases is borne by multiple payers in the U.S.; in England, therapies and health services are paid from a single source. These disease areas are intended to illustrate principles that have wider applicability across other rare diseases.

To compare the payment models, the study measured each model's 10-year net present value (NPV) of the total expected financial exposure to the initial payer—that is, the NPV of the difference between revenues and expenses over that period. The

NPV includes the treatment cost of the curative therapy and the expected costs for the patient after treatment, offset by the annual premium and any incoming revenue.

Following are key observations from the study:

- Based on sensitivity testing, the health currency model seems to be more appropriate when there is high turnover or when there is a large cost difference between the annual cost of care in the pre-cure and post-cure scenarios. Based on the modeled assumptions, health currency results in the greatest financial protection to a payer with potential member turnover (i.e., multipayer system), because it offers the largest potential for revenue collection through its clawback feature.
- The two insurance-like models—multiyear insurance and industry pooling—fared better when used for cystic fibrosis, which is currently less expensive on average to treat than hemophilia, pre-cure. These two approaches can considerably reduce (with multiyear insurance) or even eliminate (with industry pooling) the impact of membership turnover and ultimately help address the free-rider problem. In healthcare, the free-rider problem may occur when the entity funding an intervention or treatment is different from the entity deriving the financial benefits.
- Industry pooling and multiyear insurance make more financial sense when the loss ratio (i.e., the ratio of expenses to premiums) in years following the cure administration is less than 100%. Locking a member in for longer-term durations when the loss ratio following the cure administration is above 100% will increase the financial risk exposure to the initial payer, relative to a scenario with year-on-year member turnover.
- For a payer with no turnover (i.e., a single-payer system), all the alternative payment models provide the same level of financial exposure, except for the models with effectiveness guarantees. The effectiveness guarantee provides the payer with protection from the failure of the therapy. For all other payment models, the payer would be exposed to this risk.
- As the efficacy of the curative therapy decreases, the payment models with an effectiveness guarantee provide the greatest financial protection to the payer. Thus, the value of this guarantee will increase as the uncertainty around efficacy rises.
- Unlike other payment models, the annuity payment system allows spreading the up-front cost of curative therapy over a defined long-term horizon. However, in a single-payer system with budget prioritization and allocation occurring annually, this may increase equity concerns.
- An annuity model can also be developed to incorporate various conditions for payment to mitigate risks such as mortality, membership turnover, and the efficacy and durability of the therapy. In our modeling, turnover is the most significant risk, which is most relevant for multipayer systems.

The proposed alternative payment models are assessed against certain evaluation criteria to highlight the strengths and weaknesses of each approach. Table 1 presents the assessment results from this study.

Table 1
Core Criteria-Based Assessment of Payment Models

| Payment Models | Core Criteria | | | | |
|---|--|--|--|---------------------------------------|--------------------------------------|
| | Reduces Total Risk Exposure to Initial Payer | Reduces Efficacy Uncertainty About Value | Enables Risk Pooling at Population Level | Spreads or Delays Payment of the Cure | Minimizes Barriers to Implementation |
| <u>Insurance-like</u> | | | | | |
| Industry pooling | X | X | √ | X | √ |
| Multiyear insurance | X | X | X | X | √ |
| <u>Debt-like</u> | | | | | |
| Annuity payments | √* | X | X | √ | X |
| Annuity payments with effectiveness guarantee | √* | √ | X | √ | X |
| Health currency | √ | X | X | X | X |
| Financial bonds | X** | X | X | √ | X |
| Financial bonds with effectiveness guarantee | √* | √ | X | √ | X |

*It is theoretically possible that selected conditions for payment or effectiveness guarantee reduce the total financial exposure to the initial payer. In practice, the manufacturer may decide to reflect this financial risk in the price of a curative therapy or to collect additional payments from follow-on payers. Yet we note that a payer may not value a given risk in the same way as a manufacturer or third-party entity.

**The total financial exposure to the initial payer is reduced only in the special case where the bond coupon rate is smaller than the discount rate.

There is no single payment model that meets all the criteria, and some of the payment models, such as the health currency and multiyear insurance, would not be practical in single-payer systems. Moreover, barriers to implementation may exist for debt-like models. In a multipayer system, there is also the free-rider problem, which could be mitigated by industry pooling, multiyear insurance, and health currency. Ultimately, the summary grid (Table 1) highlights the strengths and weaknesses of each payment model, which precludes a one-size-fits-all approach to the payment of high-cost curative therapies.

Background

A new wave of gene therapies, CAR-T cell therapies and other curative therapies targeting rare diseases are in the pipeline and are expected to enter the market in the coming years. Among the factors driving this trend are scientific advancements, greater precision of diagnostic coding and considerations around unmet need (Bearryman 2016). In the United States and England, it is estimated that the prevalence of people with a rare disease is about 1 in 11 (NIH 2017) and 1 in 17 (Genetic Alliance 2018), respectively, most of which are a result of genetic conditions. The definition for what constitutes a rare disease varies. In the United States, it is defined as a disease affecting fewer than 200,000 people; in Europe the threshold is less than 1 in 2,000 people (NIH 2017). Individually, rare diseases may not pose a threat to current drug-financing mechanisms, due to the small size of the affected populations, but collectively, these diseases have the potential to be disruptive to payers.

Until recently, conventional therapies and other maintenance treatments for more prevalent chronic conditions seemed to receive greater attention than curative therapies targeting rare diseases. Conventional therapies generally target larger populations and aim to slow disease progression or alleviate symptoms. These therapies are dispensed over a sustained period of time, delivering clinical benefit closely timed to the expense of the medication. This chronic condition drug landscape changed with the launch of the innovative treatments for hepatitis C, which are reported to cure 95% of patients after only 12 weeks of treatment (WHO 2017).

Current funding mechanisms for health care services are structured to cover costs incurred at the time the service is delivered. For chronic conditions, this often means payers are responsible for funding recurring costs for the life of the patient (or at least for the length of time the patient is covered by the payer). This mechanism may not be well equipped to address the potentially substantial one-time budget impact associated with curative therapies. Additionally, in a multipayer system, the future medical expenses forgone due to the curative therapy may not accrue back to the payer entity funding the new treatment, due to the risk of member turnover. Ultimately, this adds complexity to the way a payer may value these new therapies, no matter how effective.

Uncertainty about the efficacy and durability of curative therapies adds an additional level of financial uncertainty to the realization of value. Clinical trials for rare diseases often include very few patients. Additionally, the trials may have produced observations for a limited time period at the time of regulatory review by the Food and Drug Administration (FDA) in the United States or European Medicines Agency (EMA) in Europe. The payer entity may have concerns about an unproven duration of benefit, particularly in the first year or two following approval, and given the small treatment population size.

Several payment mechanisms are proposed in the literature as potential solutions to address the unique concerns of curative therapies to payers: up-front treatment costs, efficacy and durability. Some are already in use in other industries and have the potential of being applied in health care, while others are health-care-specific solutions. Regardless of their origins, these proposed alternative payment mechanisms tend to adhere to one of two categories: insurance-like models or debt-like models. The key characteristics and key risks for each of the suggested alternative payment models have not yet been systematically presented across a range of predefined criteria and/or payer perspectives.

Scope and Limitations

This research report relies on illustrative scenarios and assumptions made by the authors to consolidate and summarize key considerations around the payment and allocation of risk for future high-cost curative therapies targeting rare diseases.

Unlike other existing frameworks that focus on value determination, this research aims to highlight the strengths and weaknesses of each payment approach across several payer perspectives. It also acknowledges the need for a tailored response to the funding and affordability challenges of high-cost curative therapies.

In practice, the disease-related metrics, costs and specific contracting terms of the alternative payment models may differ significantly from what has been modeled. Additionally, this modeling was strictly limited to focusing on the initial payer's perspective; "initial payer" in this context refers to the entity funding the cure. Thus, the effect of a curative therapy on patient cost sharing, treatment centers, specialty pharmacies, providers or other relevant distributors or stakeholders was not considered. For these reasons, this research is not intended, nor should it be used, for any of the following purposes:

1. Informing the potential price paid for a curative therapy for the disease areas selected or others
2. Linking the hypothetical price of a cure used in our illustrative examples to the expected cure efficacy and/or to the current annual cost of treating patients with selected disorders
3. Contemplating the evolution of potential alternative payment models if payer systems were restructured (perhaps to reflect a purchasing consortium) or manufacturers offered portfolio-wide "bundling" of curative therapy contracts.

For this study, a curative therapy is defined as a therapy that (a) improves a person's clinical state or cures a condition for a sustained period of time and (b) is administered once, up-front.

The focus of this research is not on the quantitative values, but rather on the extent to which each of the proposed payment models can diversify or mitigate financial risk. Given the decision by the initial payer to cover a curative therapy, the study examines the extent to which alternative payment models can mitigate the inherent risks associated with an up-front cost for a treatment with long-term durability, using a consistent set of assumptions. Arguably, the magnitude of the risks (and, presumably, the need for mitigation) increases as the cost of the cure increases. While the decision to approve the treatment may be affected by cost relative to a benchmark, this study contemplates payment models under the assumption that approval is already granted. Therefore, this study does not seek to influence a payer's decision to cover or not cover curative therapies.

We note that the FDA in the U.S. has not provided guidance as to the minimum expectation for the efficacy of a drug in order for it to be approved. Notably, two CAR-T therapies were recently approved by the FDA based on their Phase I/II results alone (National Cancer Institute 2017). In our research, the focus is on the sensitivity of the alternative payment arrangements to a range of potential assumptions. When efficacy rates are lower (or less certain), payment models that provide some contingency related to efficacy will be evaluated more favorably. When efficacy rates are higher, that provision has lower value.

Among "traditional" therapies, studies have found that real-world performance often differs from what has been demonstrated in clinical trials. This difference can be attributed to differences in medication adherence and to the use of the therapy in a broader patient population (e.g., clinical trials may enroll individuals with fewer comorbid conditions). The performance of high-value therapies may be very similar to what has been demonstrated in clinical trials because (a) adherence is not an issue with a one-time administration and (b) the patient-screening process may be highly prescriptive.

Evaluation Framework

The overarching purpose of this research report is to assess alternative payment models for one-time high-cost curative therapies, using a common set of assumptions and evaluation framework. The complexity and specificity of these new drugs precludes a one-size-fits-all approach to payment.

A large number of potential alternative payment models are presented in the literature, yet no systematic review is currently available to support a comparison across a variety of payment models. To enable this type of comparison, we created an evaluation framework that will identify potential sources of risk to the payer and the extent to which the alternative payment models address those risks. It also relies on criteria specific to each payer perspective and recognizes that alternative payment mechanisms may not be relevant (or necessary) to all payers.

We focus on potential payment models that could be instituted between an initial payer (entity paying for the cure) and one or more third-party entities (such as the pharmaceutical manufacturer, other payers or a financial institution), once a decision to provide a one-time curative therapy to a single patient has been made. We explore the opportunities and risks embedded in each of the payment approaches selected from the financial perspective of payers. Much has already been written about provider-insurer alternative payment models; thus, our aim is to broaden the scope of analysis and demonstrate the financial effect of various risk-sharing arrangements within the context of one-time curative therapies.

This section will introduce the reader to three aspects of our study:

1. The payment models under review
2. The payer perspectives selected
3. The criteria used to evaluate the payment models and the summary evaluation grid

Payment Models

The expected front-loaded budget impact of high-cost technologies, particularly novel curative therapies, has the potential to be disruptive to payers. A total of seven approaches are selected for consideration as potential alternative payment models for high-cost curative therapies. They include approaches found in literature and additional ones chosen by the authors based on their research experience. Insurance-like and debt-like funding models are separated to help with understanding the considerations specific to each category. This list of selected approaches is not exhaustive, and variations may exist. However, it is intended to represent the range of potentially available financing options, each with its own merits, drawbacks and complexities.

Insurance-Like Models

Insurance-like payment models refer to approaches that draw on health insurance principles or are extensions of principles currently in use in the health care industry. They support the view that existing insurance mechanisms, or subtle variations of them, could be adopted as potential payment methods. Therefore, the payment associated with a one-time curative therapy is borne up front. Table 2 describes each insurance-like model within the context of high-cost curative therapies.

Table 2
Insurance-Like Payment Models

| Proposed Models | Description |
|----------------------------|---|
| Industry pooling | This pooling mechanism spreads the up-front cost of cure and residual cost of care among all participants in the pool (e.g., payers) to protect an individual entity from bearing the full financial burden of high-cost curative technologies. Several forms of industry pooling can exist, including voluntary or nonvoluntary, as well as profit and nonprofit associations. In this study, the industry pool is the initial payer. We acknowledge that, in practice, contributions into the pool would be made by a group of payers on a per member basis (i.e., relative to payer membership). |
| Multiyear insurance | The multiyear mechanism is a longer-term health insurance policy that provides the insured with multiple years of insurance protection, rather than the typical one-year short-term policy duration usually provided by health insurers. Note that this product may exist in some countries and markets, and coverage may be offered at various durations. For illustrative purposes, we use three-year and five-year insurance contracts. |

As noted previously, other insurance-like models could be appropriate. Given the concerns that payers may be unable to bear the cost of one-time curative therapies, it may seem unrealistic to expect a single provider or a group of providers to take on this risk. Provider-centric models, such as bundled payments and disease capitation, could mitigate the cost of a curative therapy to the payer. Alternatively, reinsurance or stop-loss insurance could spread the financial risk across multiple payers and decrease the uncertainty of costs in a given year by replacing them with a per member premium. However, these mechanisms do not fund the therapy directly, and they ultimately shift some of the financial risks to care providers or secondary insurers. Therefore, these models were not included in this analysis.

Debt-Like Models

In contrast, the debt-like payment models described in Table 3 draw on the concept of outstanding balance. While the timing for payment can be established at agreed-upon intervals, it may not necessarily be known in advance, particularly when payment is tied to trigger points like membership turnover or mortality, for instance. Ultimately, the timing of payment will vary depending on the payment models and terms of the contract, and its size will be determined by the cost of therapy and the use of amortization.

Table 3
Debt-Like Payment Models

| Proposed Models | Description |
|--|--|
| Annuity payments | Annuity payments are also proposed in the literature (Jørgenson and Kefalas 2017) to spread the full up-front cost of a new therapy over the expected duration of clinical effect. This model is also sometimes referred to as “leasing” (Hettle et al. 2017). Several conditions for payment can be included under an annuity-based scheme, and payments can be made over time from the initial payer to the manufacturer. Alternatively, a third-party entity could pay the manufacturer up front and receive the annuity payment over time. |
| Annuity payments with effectiveness guarantee | This model extends the prior model by incorporating an outcomes-based agreement to address efficacy uncertainty. The expected future stream of payments from the payer to the manufacturer or third-party entity is conditional upon the delivery of clinical benefit in line with clinical trial results, or according to predefined clinical metrics (Edlin et al. 2014). |
| Health currency | A payer funds the therapy up front, and a “health currency” is created upon administration of the therapy (Mattke et al. 2016; Basu 2014). If the treated patient changes insurers, the initial payer is paid a predetermined percentage of the forgone future financial savings related to the therapy. This clawback percentage is applied every year following membership turnover for a preestablished time frame (e.g., 10 years) and corresponds to the difference in the amount at risk (claims minus premiums), based on the expected value delivered by the therapy for the follow-on insurer. This is a novel approach and is not currently in use. A case study is included in this section to provide further clarity. |
| Financial bonds | Payment for the cure is delayed until a later date, and interest payments (similar to coupon payments) are paid by the initial payer at established intervals and agreed-upon interest rates. The principal amount, equal to the cost of the cure, is repaid at bond expiry. Bond payment can also occur at selected trigger points, such as death or turnover, according to the terms of the contract, adding some unpredictability to the timing of the repayment of the principal amount (Mattke and Hoch 2015). Under this scheme, the |

| Proposed Models | Description |
|---|--|
| | manufacturer may still receive payment for the cure up front. In this case, a third-party entity, such as a financial institution, would issue the financial bond and collect coupon and principal payments over time. |
| Financial bonds with effectiveness guarantee | This model extends the prior model by incorporating an outcomes-based agreement to the coupon and principal payment model to address efficacy uncertainty. In the event the patient does not respond to treatment, the bond would default, and the principal would not be paid in full. The manufacturer or third-party entity may be at risk, depending on the terms of the contract. |

Case Study: Health Currency

Health currency is a novel potential payment model that has not yet been implemented or tested in practice. As such, we present an example on how the mechanics underlying this approach would work. As noted in Table 3, the health currency model allows a payer to receive a clawback payment—a predefined percentage of the forgone expected savings related to the cure—after a successfully treated patient leaves the payer. The clawback payment is paid by the follow-on insurer and any other subsequent insurers to the initial insurer.

Table 4 illustrates an example of the approach when a member moves to a new commercial insurer. The clawback percentage applies to the difference between expected cost and expected premium to the follow-on payer for a hypothetical no-cure scenario and between the actual cost and actual premium to the follow-on payer in the post-cure.¹ The initial payer would be able to claim back any forgone savings only if a cure is achieved and is sustained over a defined time frame. The scenario considered is purely illustrative, with the following assumptions:

- Medical underwriting may not be used in determining the premium. Premiums among commercial payers may differ.
- The initial payer’s expected cost of care is assumed to be similar to those of follow-on payers.
- The clawback is assumed to be 10%, and the residual cost of care following a cure is set at 5%.
- The curative therapy is provided up front at the start of year 1 and sustained over the five-year time frame.
- Member turnover occurs in year 3, so clawback payments would be evaluated annually from year 3.

Table 4
Health Currency Example

| | Year 1 (Cure) | Year 2 | Year 3 (Turnover) | Year 4 | Year 5 |
|--|--------------------------|--------------------------|--------------------------|------------------------|------------------------|
| Expected cost of care to initial commercial payer (if no cure) | \$150,000 | \$155,000 | | | |
| Expected cost of care to follow-on commercial payer (if no cure) | | | \$160,000 | \$165,000 | \$170,000 |
| Actual residual cost of care to initial commercial payer (post-cure) | 5% × \$150,000 = \$7,500 | 5% × \$155,000 = \$7,750 | | | |
| Actual residual cost of care to follow-on commercial payer (post-cure) | | | 5% × \$160,000 = \$8,000 | 5% × 165,000 = \$8,250 | 5% × 170,000 = \$8,500 |
| Expected premium to initial commercial payer | \$6,250 | \$6,500 | \$6,750 | \$7,000 | \$7,250 |
| Expected premium to follow-on commercial payer | | | \$7,500 | \$7,750 | \$8,000 |

¹ The no-cure scenario is hypothetical because the curative therapy was already funded by the initial payer, but potential savings to the follow-on insurer are calculated as financial and clinical benefits of the curative therapy accrue to the follow-on payer.

| | | | | | |
|---|--|--|--|--|--|
| Clawback @ 10% of forgone future savings | \$0 (Member is still with initial payer) | \$0 (Member is still with initial payer) | $((\$160,000 - \$6,750) - (\$8,000 - \$7,500)) \times 10\% = \$15,275$ | $((\$165,000 - \$7,000) - (\$8,250 - \$7,750)) \times 10\% = \$15,750$ | $((\$170,000 - \$7,250) - (\$8,500 - \$8,000)) \times 10\% = \$16,225$ |
|---|--|--|--|--|--|

Two of our assumptions—that the expected cost of care to the initial commercial payer will be similar to that of the follow-on commercial payer and that premiums may differ between commercial payers—may differ from reality for a variety of reasons. Particularly, where the cure is not provided, computing what the cost of care would have been under the hypothetical scenario or determining the corresponding level of premium may be logistically difficult. Therefore, for the purposes of calculating the clawback payment, reference or benchmark metrics for the hypothetical cost of care and premium may be established and used uniformly across payers.

Payer Perspectives

Financial risks can be unique to each health payer and will arise within the context of high-cost curative therapies.

Understanding the nature and degree of financial risk exposure of single-payer systems and multipayer systems can help with identifying the most appropriate alternative payment model across payers.

Single-Payer System

In a single-payer environment, the majority of the cost of health care is the responsibility of one entity. Individuals have the ability to enroll—regardless of their health status—in these systems and will receive coverage throughout their lifetimes. Because individuals are associated with the payer for longer time horizons, the clinical benefits from new interventions accrue back to the payer that funded the treatment. Nonetheless, single payers are still at risk for mortality, unrealized clinical efficacy or durability, and large unbudgeted financial outlays. In this research report, the National Health Service (NHS) in England serves as proxy for analyzing payment considerations relevant to countries or systems with a single-payer entity.

Multipayer System

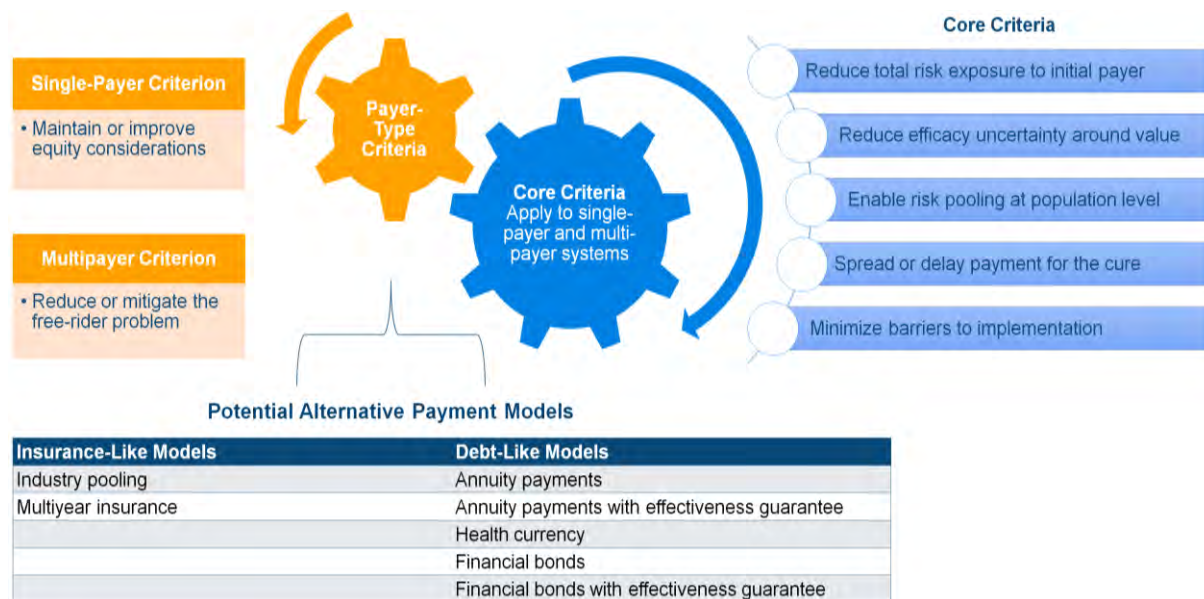
In a multipayer environment, the cost of health care may be shared by more than one payer, including but not limited to private payers (e.g., insurance companies, self-insured employers) and government-funded programs (e.g., Medicare, state Medicaid agencies). Over a patient’s lifetime, he or she will likely receive health coverage from multiple sources or insurers. Aging out of a parent’s plan, aging into Medicare, changing jobs, or being a part of a fully insured employer that shops for lower premiums are all reasons a person could change health insurers. The potential for membership turnover, or “churn,” causes the free-rider problem. The free-rider problem arises when the clinical benefits and financial offsets associated with an intervention do not accrue back to the payer that funded the intervention. The free-rider problem is most significant when payers in the multipayer system adopt the intervention at different rates.

This research draws on the experience in the United States to highlight payment considerations in multipayer systems. It focuses primarily on the private commercial insurance market, but the discussion section of this report also explores the risks to government-funded programs like Medicaid and Medicare. Appendix A provides additional information on the drug evaluation and reimbursement processes in England and the U.S.

Evaluation Criteria

An important step in the evaluation of payment approaches for curative therapies is establishing relevant criteria by which to assess the various funding options individually. We identified a list of seven evaluation criteria—five core criteria that apply to all payer systems and two additional criteria that are payer specific. Some of these criteria can be found in existing frameworks. The majority of the criteria were adjusted to meet the scope and objectives of this research and are tailored to each payer perspective. Figure 1 illustrates how the multiple components of the evaluation framework are related.

Figure 1
Evaluation Framework



Core Criteria

Five core criteria are included in this evaluation framework (see Table 5). These apply to single-payer and multipayer systems.

Table 5
Core Evaluation Criteria

| Core Criteria | Description |
|--|--|
| Reduce total risk exposure to initial payer for providing the cure | This criterion measures whether the approach can reduce the expected total financial burden to the initial payer for funding a curative therapy relative to a scenario where no funding mechanism (up-front payment) and effectiveness guarantee are provided. |
| Reduce or mitigate efficacy uncertainty around value | There is currently considerable uncertainty about future curative therapies expected to enter the market in the next few years. Payers can be uncertain about the value of new treatments, and this consideration is particularly important given the relatively high prices anticipated for these new therapies. This criterion measures the degree to which each alternative model proposes to either reduce or mitigate some of the uncertainty around the value of potential curative therapies. |

| | |
|---|---|
| Enable risk pooling at population level | Some risks can be reduced or mitigated when a more holistic population view is adopted. This criterion evaluates whether the approaches can be implemented at a population level (in addition to patient level) to diversify risk. |
| Spread (or delay) payment of the cure over duration of benefits | One of the challenges of curative therapies is the potentially high up-front cost of cure. This criterion measures the ability of payment models to either (a) spread the up-front cost of curative therapy over the period clinical benefits are expected to be recognized, or (b) delay the full payment of the cost of cure until a later date. Various time horizons can be used: short term (0–3 years), medium term (3–9 years), or long term (10 years and above). |
| Minimize barriers to implementation | This criterion assesses the degree of implementation feasibility and design constraints. Some payment models are developed on a theoretical basis and have not been tested. This criterion therefore assesses the degree to which the current administrative, data and system capabilities would support each approach and whether adjustments to the current legal or accounting framework would be required. |

Payer-Specific Criteria

The evaluation framework also incorporates additional criteria relevant only to single-payer or multipayer systems. These criteria, described in Table 6, complement the core criteria presented in Table 5.

Table 6
Additional Payer-Specific Criteria

| Payer-Specific Criteria | Description |
|--|--|
| <u>Single-Payer System</u> | |
| Maintain or improve equity considerations | Some alternative payment approaches propose to reallocate the up-front costs of the curative therapy over time. Recognizing current costs at a later point in the future may increase financial burden for future generations by constraining future budget allocation decisions. This has some important ramifications for single-payer entities with fixed budgets, which are normally bound by intergenerational and other equity considerations. |
| <u>Multipayer System</u> | |
| Reduce or mitigate free-rider problem | The free-rider problem typically arises in a multipayer environment when the payer funding an intervention is different from the entity receiving the financial benefits from treatment. High membership turnover is a key cause of this problem. |

Illustrative Scenarios and Model Results

The decision by payers to enter into an alternative payment arrangement to fund a one-time high-cost curative therapy depends on many factors, including the following:

1. Total expected budget impact and expected duration of clinical benefits
2. Payers' ability to capture future financial benefits and financial offsets linked to this new treatment
3. Degree of uncertainty around efficacy

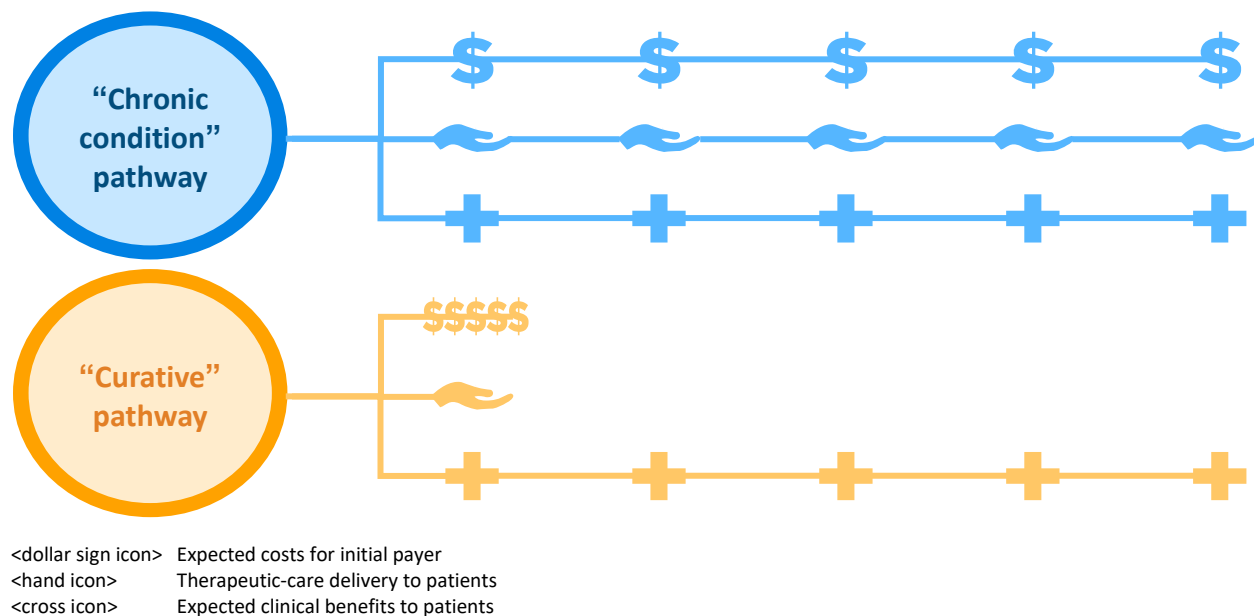
Ultimately, the model selected to pay for a one-time curative therapy will be specific to the type of payer, the characteristics of the disease areas, and the financial risks that the manufacturer and the payer are willing to share or mitigate.

This research relies upon illustrative examples and assumptions made by the authors. In practice, the disease-related metrics, costs and specific contracting terms of the alternative payment models may differ significantly from what has been modeled.

Context: Chronic vs. Curative

Current funding mechanisms (i.e., taxes for national health systems and premiums for private health insurers) are structured to cover the expected costs of treating patients. Using the analogy of a chronic condition treated with traditional therapies, costs to payers and clinical benefits to patients are occurring on a somewhat recurrent basis, year on year. Health insurance premiums are set such that the premiums received are expected to adequately cover the total expenses paid out for health services and treatments incurred during the policy year. But in the case of a one-time high-cost curative therapy, there is a mismatch between the up-front treatment costs, delivery of care to patients and long-term realization of clinical benefits to patients, as seen in Figure 2.

Figure 2
Incurred Costs, Therapeutic Administration and Clinical Benefits: Chronic vs. Curative Timeline



The free-rider problem also will occur if the clinical benefits and financial offsets linked to the curative therapy do not accrue back to the entity funding the intervention. This problem is particularly prevalent in multipayer systems where multiple payers

or insurers compete for members at policy expiry, usually every 12 months. Annual membership turnover accentuates these financial pressures. Some of the proposed alternative payment models specifically address the free-rider problem.

Further, therapies targeting chronic conditions tend to alleviate symptoms or slow disease progression. Therefore, the population treated each year includes both the prevalent population (those who were diagnosed in a prior time period) and the incident population (those who are newly diagnosed). In contrast, curative therapies erode the size of the patient population if treatment is successful. Once the prevalent population has been treated, only the incident population remains.

Finally, it is important to highlight that, as of the date of writing this report, no curative therapies have yet launched for the two rare diseases used as our examples. The scenarios illustrate the potential financial implications to commercial payers of moving away from current standards of care and toward curative therapies to treat patients with selected rare chronic conditions. We relied on real-world claims data to inform the assumptions of the model, but the precise values are less important than the nature and timing of the cash flows. The aim is to evaluate and consider potential payment models in anticipation of potential future curative therapies in these or similar disease areas, using illustrative scenarios. Our analysis does not intend to capture the total cost burden of a given disease area to payers, but rather focuses on relevant financial risks for single-payer and multipayer systems as treatment patterns shift from chronic treatment to a one-time curative therapy.

Disease Areas Selected in Modeling

To evaluate the proposed alternative payment models, we consider two rare conditions: hemophilia and cystic fibrosis.²

Hemophilia is a genetic disorder that prevents the blood from clotting normally, causing excessive bleeding spontaneously or after injury. The majority of hemophilia patients, especially the most severe cases, are males. Patients with hemophilia, estimated at 20,000 and 6,000 in the U.S. and England, respectively, are treated using factor replacement products, which can be administered prophylactically or on demand (National Hemophilia Foundation 2018). Factor replacement products are expensive and can be burdensome to administer, but they allow the majority of people with hemophilia to adequately manage the condition. The average annual paid cost of care in 2015 was \$161,663 in the U.S. commercial data sample we analyzed, but this can vary widely from patient to patient. While there is currently no cure for hemophilia, gene therapies are in the pipeline (Pickar and Gersbach 2018), thus making hemophilia a suitable candidate for this study.

Since the introduction of improved blood screening procedures and the development of recombinant factor products (American Society of Hematology 2008), people with hemophilia can now expect to live almost as long as the average individual and so can have health coverage from commercial insurers, Medicaid and/or Medicare over their lifetimes. In England, all services and treatments for hemophilia are paid directly by NHS England through specialized services (NHS England 2018). Most of these services are paid from a single source, due to the large financial cost of care related to this condition, allowing this condition to be studied from the perspective of a single-payer system, too. In England, a single funding mechanism is typically used to cover high-cost, low-frequency diseases and protect the regional payers from taking on this risk. NHS regional Clinical Commissioning Groups, which are typically responsible for the payment of most health care services for their geographically defined populations, do not cover any elements of this service.

Cystic fibrosis is a genetic disorder characterized by the buildup of mucus that can damage the lungs and other organs and can lead to problems with the respiratory and digestive systems (NIH 2018). It has a prevalence of over 30,000 and 8,000 in the U.S. and England, respectively (Cystic Fibrosis Foundation 2018; UK Cystic Fibrosis Trust 2017). It is usually diagnosed at birth, with the large majority of cases diagnosed by age 2, yet some cases are diagnosed later in childhood and adulthood. The management of cystic fibrosis has improved over the last decade, but there is no cure for cystic fibrosis. The average life expectancy of patients with cystic fibrosis is around 40 years old (British Lung Foundation 2018), which allows us to analyze the impact of mortality risk on the results. In the U.S., the majority of the cost of treating patients with cystic fibrosis is covered by commercial payers, Medicaid and/or Medicare (i.e., enrollment may be based on work history and Social Security Disability

² Hemophilia A and B are considered together to increase the data sample size.

Insurance status). Similarly to hemophilia, cystic fibrosis in England is a condition paid directly by the national health system through a single entity (specialized commissioning), again allowing this disease area to be analyzed under the lens of a single-payer system. The average annual paid cost of care in 2015 was \$44,169 in the U.S. commercial data sample we analyzed. This is about one-fourth the average paid cost of care observed for hemophilia in our analysis sample.

Modeling Metrics

The analysis captures paid costs related to the one-time curative therapy (direct) and projects the residual health resource needs over a 10-year period for a given member from the perspective of a commercial insurer in the United States. Residual costs can be associated with the failure of the one-time therapy (if it is not effective or not durable) and/or can be associated with an incomplete restoration of full health. Premiums and other revenues to the initial payer within this time frame also are included in the scope. We rely on patient-level 2015 medical and pharmacy claims databases to inform the annual disease-related experience of patients with selected diseases, in order to have a basis for the residual costs. Only members with full 12-month coverage of medical and pharmacy insurance are included.³ The modeling results are drawn from a commercially insured population in the U.S., but considerations relevant to Medicaid and Medicare in the U.S. as well as in the National Health System in England are included in the discussion section of this report. Full details on data sources, code sets, and methodology and assumptions are found in Appendixes B, C and D, respectively. Table 7 summarizes the base case assumptions.

Table 7
Base Case Assumptions Across Payment Models

| Model Assumptions | Hemophilia | Cystic Fibrosis |
|---|--------------------|--------------------|
| Annual membership turnover | 15% | 15% |
| Residual cost of care, post-cure | 5% of no-cure cost | 5% of no-cure cost |
| Curative therapy efficacy | 90% | 90% |
| Hypothetical cost of cure | \$500,000 | \$500,000 |
| Discount rate | 3% | 3% |
| Bond coupon rate (set equal to discount rate) | 3% | 3% |
| Mortality load | 250% | 1,000% |
| Annual cost of care, no-cure cost* | \$185,976 | \$46,878 |
| Health care trend rate | 5% | 5% |
| Base annual premium** | \$6,250 | \$6,250 |

*The 75th percentile of the paid cost distribution for hemophilia and cystic fibrosis is used in the modeling. Further details explaining the selection of the 75th percentile can be found in Appendix D.

**Year 2015 is set as base year. For the purposes of calculating retrospective payments associated with the health currency model, we assume that the annual premium charged by the initial payer is similar to the annual premium charged by follow-on payers.

The net present value of the total expected risk exposure to the initial payer over 10 years for a treated member corresponds to the sum of expenses minus revenues:

1. **Cost of cure** (expense). This corresponds to the hypothetical amount charged by the manufacturer for a single administration cure.
2. **Annual residual cost of care** (expense). This corresponds to the weighted average of the cost of care of a patient who achieves a curative state and one who does not achieve a curative state.
3. **Annual premium and other revenue** (revenue). This corresponds to the annual revenue stream to the initial payer, which is embedded in the alternative payment model.

³ This requirement is applied so that we do not misrepresent the annual cost of care for members with less than 12 months of exposure.

Modeling Results: Hemophilia

The main modeling results are presented for hemophilia only. This is to avoid repetition, because the majority of observations apply to cystic fibrosis, and potentially to other disease areas as well. The most important distinction to note between the two diseases is the annual cost of care (pre-cure), and this will be further explored in the following section on cystic fibrosis.

Total Expected Financial Exposure to Initial Payer

We present the net present value of the total expected financial exposure to the initial payer, comparing debt-like and insurance-like payment models side by side. The full height (blue plus red portion) of the bars in Figure 3 corresponds to the sum of expenses to the initial payer over 10 years. This includes the up-front cost of the curative therapy as well as any follow-on, residual cost of care following the cure administration, discounted to time 0. The red portion represents cost offsets such as member premium and other revenue to the initial payer over the same 10-year period. Therefore, subtracting the red portion from the full height of the bar gives the total expected risk exposure to the initial payer (blue portion). Figure 3 illustrates the impact of costs and cost offsets to the total NPV for each payment model under consideration. The calculation accounts for mortality, cure efficacy, turnover and other modeling assumptions appear in Appendix D.

Figure 3

Total Expected NPV to Initial Payer: Hemophilia

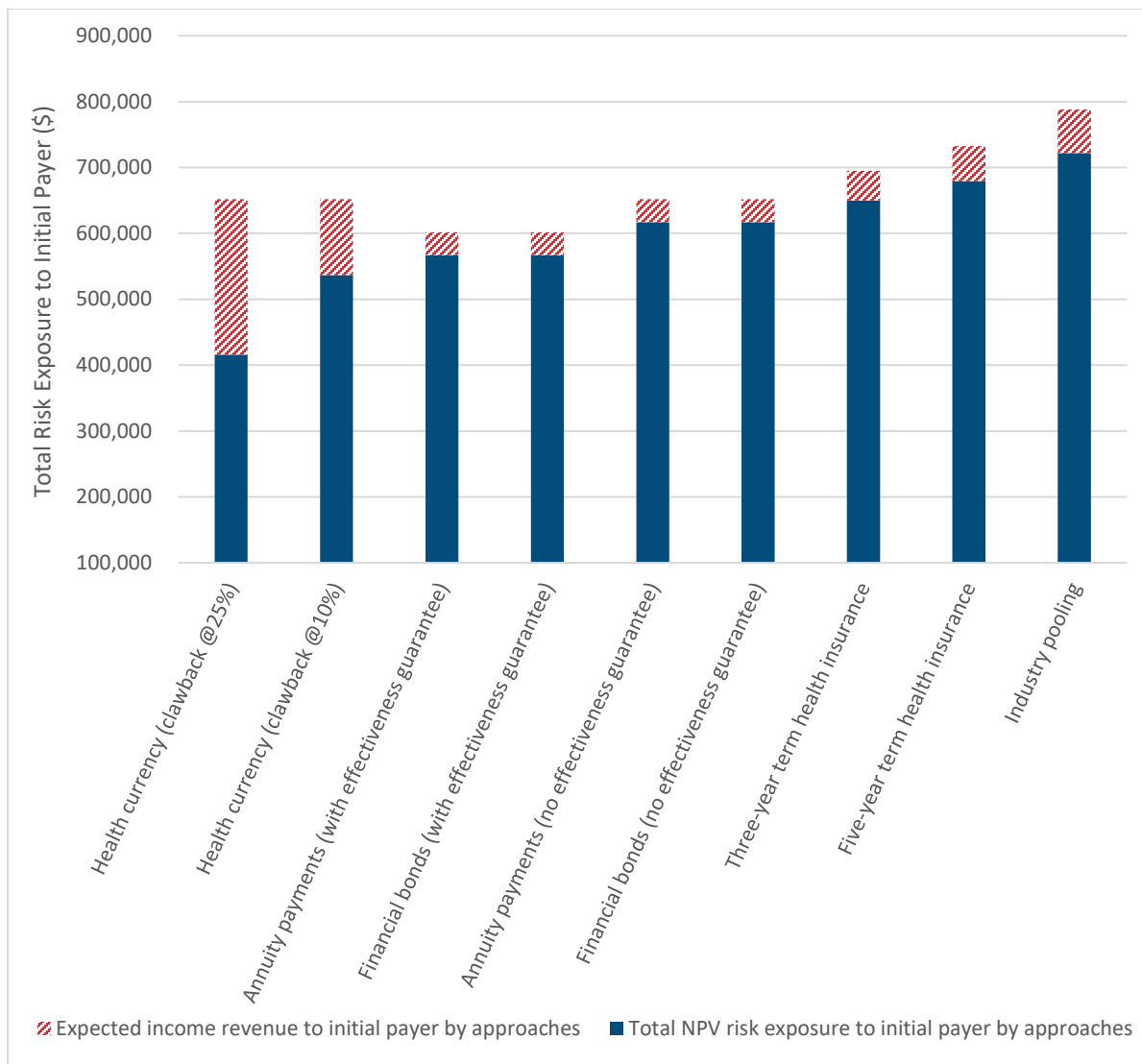


Figure 3 shows that debt-like approaches reduce the payer’s total expected financial exposure relative to insurance-like counterparts. This is mainly due to the relationship between membership turnover and cost, as well as between membership turnover and premium revenue. For instance, the multiyear insurance and industry pooling approaches are able to lock in a member for a definite duration (multiyear insurance) or indefinitely (industry pooling), which partially or fully mitigates the free-rider and adverse selection problems. This is because these models allow the initial payer to accrue the expected financial benefits following the cure administration longer than the other models. However, retaining these treated members for a (potentially) longer time period also implies paying for their health costs for a longer duration. In the case of hemophilia, the scenarios modeled assume that follow-on post-cure costs are reduced by 95% relative to pre-cure baseline costs, yet these residual costs of care (5%) can still be higher than the average member premium.

Alternatively, the three-year and five-year term health insurance and the industry pooling are able to capture greater member premium revenue over a 10-year time frame, compared with the other approaches. (Note that the health currency model also captures additional revenue, but not through member premiums.) This is due to the payer’s ability to mitigate or reduce membership turnover. In a scenario where the curative therapy efficacy is 100% and the residual costs following treatment are reduced to zero, the additional member premium collected due to lower turnover would likely be larger than the expected cost.

Of all the alternative payment methods, health currency offers the largest potential of future revenue collection (the red portion of the bars in Figure 3) for the initial payer. Through the clawback feature, the initial payer can claim back some portion of expected future savings that would be forgone if a member leaves under any of the other payment models. In the following results, the clawback level is set at 10% and 25% of future forgone savings. Even at these low percentages, the clawback potentially provides the initial payer with the largest level of financial protection.

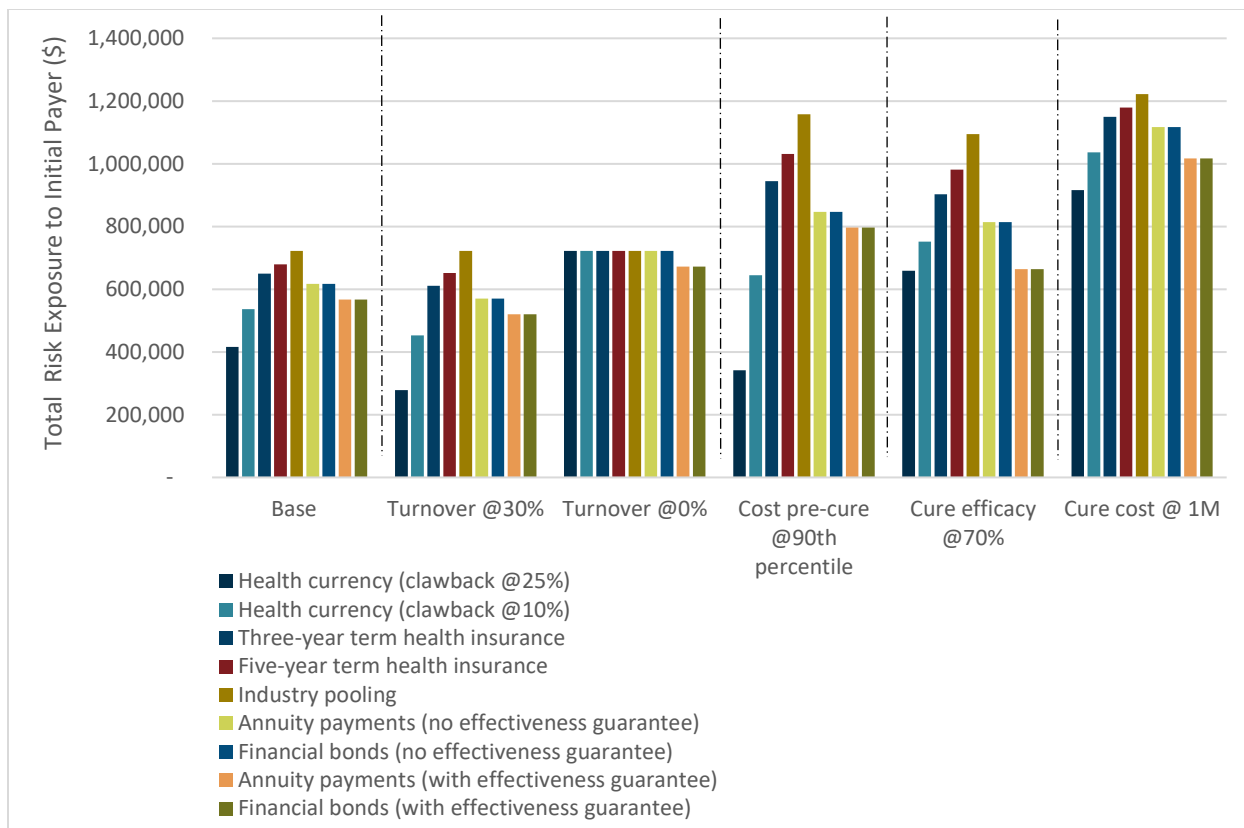
While the focus is on the total risk exposure to the initial payer (blue bar), another observation is on the full height of each bar. As mentioned previously, this represents the sum of expenses to the initial payer. We note that the annuity payments and financial bonds models with effectiveness guarantees both produce the lowest expected cost to the initial payer.⁴ The value of an effectiveness guarantee will increase as the uncertainty around efficacy rises. Overall, health currency eventually produces the lowest overall NPV, because it generates additional revenue outside of member premiums.

Sensitivity Analysis

As part of the modeling, we sensitivity-tested key model assumptions to estimate the potential influence of each assumption on the results. The total risk exposure to the initial payer under the base assumptions and alternative scenarios is presented in Figure 4, and key observations are summarized in Table 8.

Figure 4 Sensitivity Analysis Results

⁴ In theory, it is possible that an effectiveness guarantee reduces the total financial exposure to the initial payer; in practice, the manufacturer may decide to reflect this risk in the price of the curative therapy. Yet we note that a payer may not value a given risk in the same way as a manufacturer.



Note: The total risk exposure to the initial payer for the two financial bonds scenarios (with and without effectiveness guarantee) are identical to those under the annuity payment system.

Table 8
Summary of Sensitivity Analysis Results

| Model Assumption | Observations |
|-------------------------|--|
| Membership turnover | <p>In the U.S., the turnover rate varies depending on the payer. For payers with a turnover rate higher than the base assumptions (30% versus 15%), the health currency model provides the greatest level of financial protection. The other payment models produced similar risk exposure to the base scenario, but it is worth noting that payers with higher turnover are more exposed to the free-rider problem.</p> <p>For single-payer systems (scenario with 0% turnover), we note that all payment models with no effectiveness guarantee yield the same risk exposure to the initial payer. Thus, for these payers, the choice of alternative payment model is trivial. Only an effectiveness guarantee may reduce the financial risk exposure.</p> |
| Cost of care (pre-cure) | <p>The health currency thrives when the pre-cure cost of care is high and the post-cure cost of care is low. Therefore, as the pre-cure cost of care is changed from the 75th percentile to the 90th percentile of the distribution, the health currency is the only payment model that provides further financial protection to the initial payer. All other models witness an increase in the financial risk exposure relative to the base case.</p> |

| Model Assumption | Observations |
|---------------------------|---|
| Curative therapy efficacy | Adverse experience in curative therapy efficacy can be mitigated by effectiveness guarantees. Figure 4 shows that the annuity payments (and financial bonds) with an effectiveness guarantee considerably mitigate this downside risk to the initial payer. In our scenario of cure efficacy set at 70% (from baseline 90%), the annuity payment with an effectiveness guarantee, all else equal, provides a level of financial protection similar to even the health currency with clawback level set at 25%, because an annuity payment is made only while the therapy is still effective for the treated member. |
| Cost of curative therapy | The cost of the curative therapy is set at \$500,000 in the base case scenario. In the sensitivity analysis, we also tested scenarios at \$1,000,000 (shown in Figure 4) and \$250,000. While the total cost exposure to the initial payer changes with the cost of the therapy, we observed that the relative level of financial protection of each payment model is not influenced by the variation in the cost of the curative therapy. |

Specific to the financial bonds, we note this payment model is the most sensitive to changes in the discount rate. This is because the full payment of the cure occurs at a later date (unlike other models where the cost is borne up-front or amortized over time, as is the case with the annuity payment system).

Paying for Curative Therapy: Risks of the Annuity Payment System

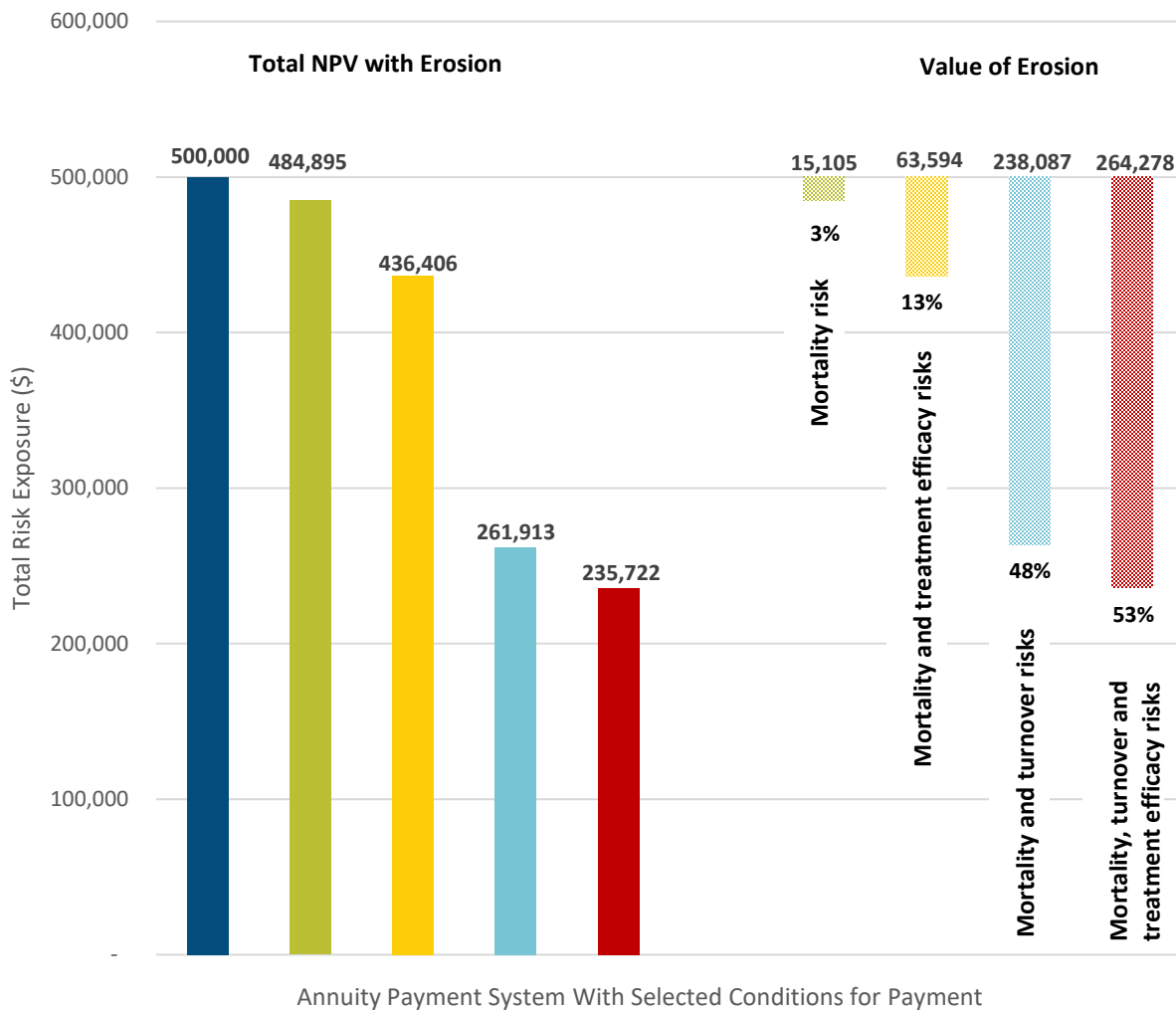
The annuity system is the only payment model that allows the up-front cost of the curative therapy to be spread over time. In all other approaches, the cost of therapy is borne either up front or later (e.g., financial bonds) but always through a lump sum amount. Therefore the annuity helps to better match the high up-front cost of a curative therapy with the expected long-term duration of the clinical benefits.

Payers face multiple risks when paying for a curative therapy up front—for instance, membership turnover, nonresponsiveness to treatment, and mortality. Including them as conditions for payment can help mitigate or spread some of the financial risks associated with the annuity payment system. For the identified risks (and potentially others), we note that a payer may not value a given risk in the same way as a manufacturer or another third-party entity. For modeling purposes, we assume a hypothetical cost of \$500,000 for the curative therapy, 15% annual membership turnover, 90% curative therapy efficacy, and 250% mortality load to the general population mortality. While these metrics will differ significantly in reality, the magnitude of the differences among these conditions for payment will remain similar to what is presented in the following example.

Figure 5 displays the total present value of the amortized annuity payments, as well as the risk value subject to erosion under various conditions for payment. The figure is intended to highlight the magnitude of each of the financial risks, which should be considered when sharing or allocating the risk to the various stakeholders. The first blue bar on the left represents a scenario where the annuity payment is used to amortize the cost of cure over time, with no conditions for payment. The remaining four solid-colored bars show the degrees to which the various conditions for payment can erode the total financial risk exposure. Together, the total NPV with erosion and the value of erosion sum to the hypothetical cost of cure. Using the same assumptions across all annuity scenarios, we observe that the membership turnover (i.e., requiring the member to be in the initial payer’s book of business) erodes the risks to the payer more quickly than mortality and efficacy. Requiring the member to be alive, in the initial payer’s books of business, and with an effectiveness guarantee would reduce the financial risk to the initial payer by over half relative to the baseline.⁵ If the mortality or turnover is greater than what has been modeled, or efficacy is lower, the conditions for payment would provide further financial protection to the initial payer than the levels shown in Figure 5.

⁵ We note that manufacturers may choose to reflect the uncertainty of incoming cash flows when developing the price of a curative therapy.

Figure 5
Risks of the Annuity Payment System



- No condition for annuity payments
- Annuity payments linked to mortality
- Annuity payments linked to mortality and treatment efficacy risks
- Annuity payments linked to mortality and turnover risks
- Annuity payments linked to mortality, turnover and treatment efficacy risks

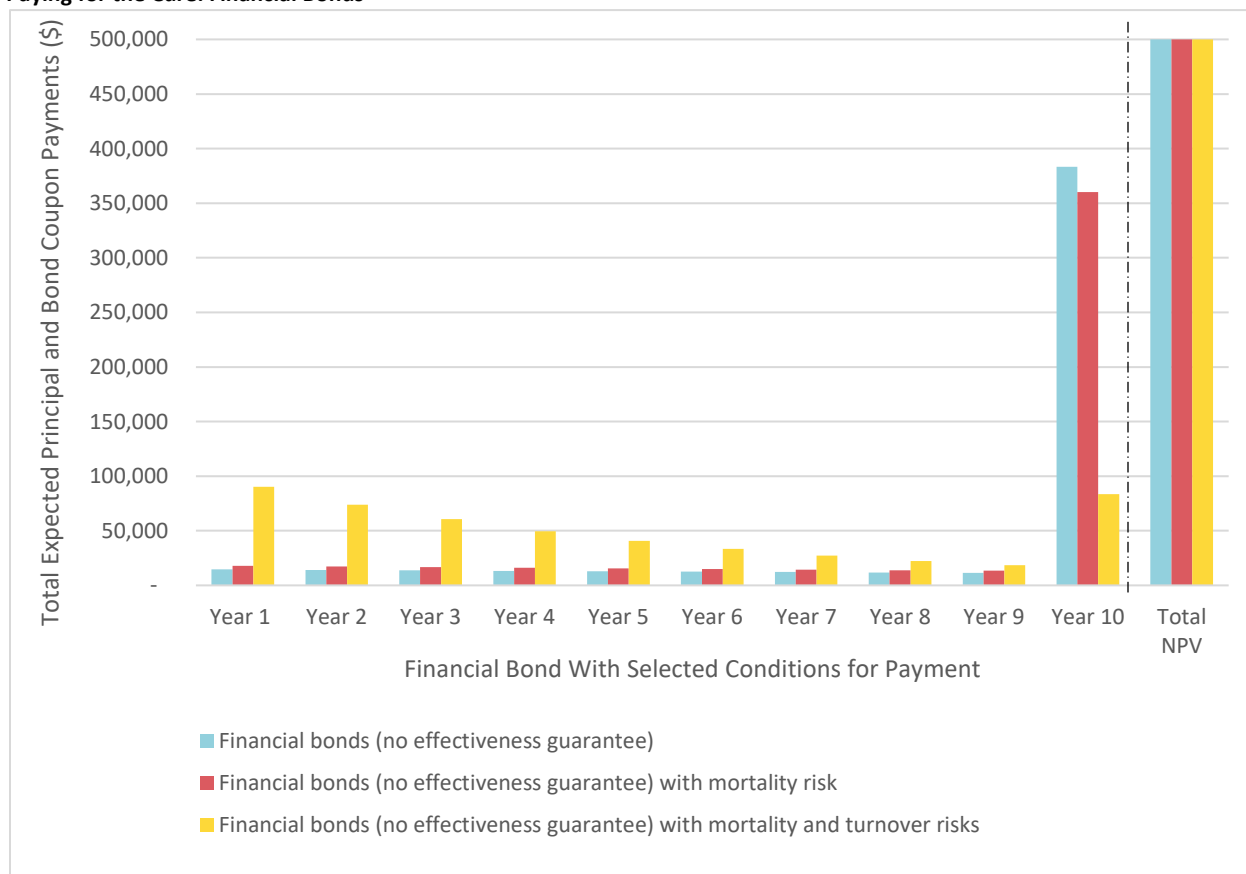
Paying for the Curative Therapy: Financial Bonds

Financial bonds can also be used to pay for a curative therapy. Unlike annuities, however, financial bonds do not spread out the costs of the therapy over a predefined time period, but instead delay the full payment of the therapy until a later date. The timing of the bond payment will vary according to the terms of the contract (i.e., at bond expiry or when the member dies or leaves the initial payer book of business). Through the use of a third-party entity like a financial institution, it is possible for the manufacturer to be paid up front for the cost of cure if the third-party entity is willing to receive payment over time from the initial payer.

In general, the payment of the cost of the curative therapy—the principal, in financial jargon—occurs at bond expiry. Bond expiry is set at 10 years in the following example. During this time frame, the payer (the bond issuer), agrees to make interest payments to a third party such as a drug manufacturer or financial institution (the debt holder), for the “use” of the curative therapy. These payments would usually be made semiannually or annually, similar to bond coupon payments exchanged in the financial world. Yet, like a bond recall, it would be possible to require bond repayment to occur prior to expiry. This could be done at predefined trigger points that are not known in advance—for instance, when the member dies or changes insurers. In the event of treatment nonresponsiveness, the bond would default, and the principal would not be paid in full.

The probability of paying for the bond in every year would reflect the risks facing the initial payer at each time point—for example, mortality or membership turnover. Thus, the cash flows from the initial payer to the third party will be higher in years that the risk of losing a member to either death or membership turnover is greater (yellow bar in Figure 6), assuming these risks are embedded within the terms of the contract. When no conditions for payment are included within the terms of the contract, the cash flows at bond expiry (10 years in our modeling) are larger than in other years, because there is a greater probability that the principal equivalent to the cost of cure will be repaid at expiry, rather than in advance.

Figure 6
Paying for the Cure: Financial Bonds



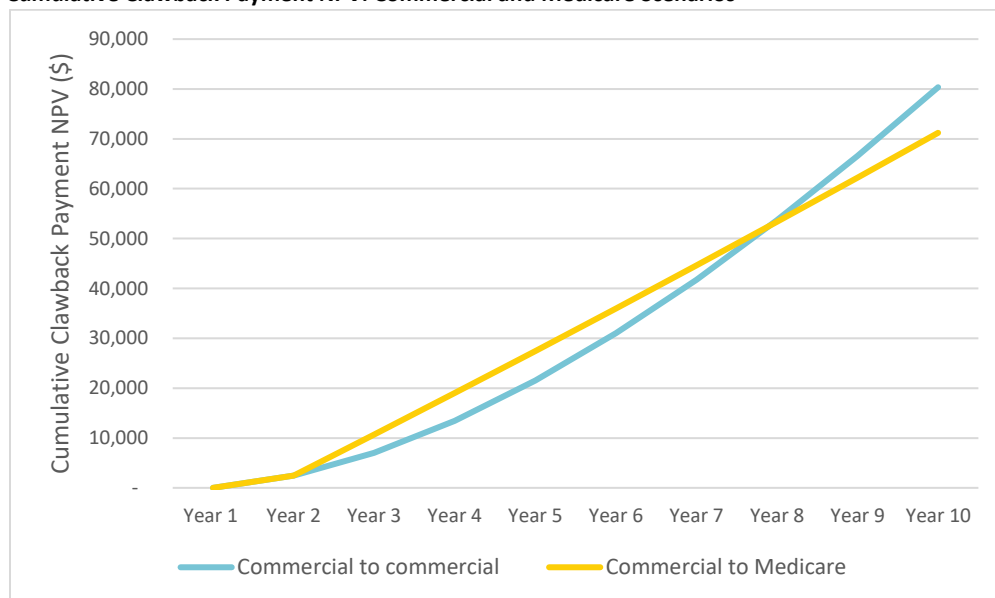
While the financial bond can integrate various conditions for payment into the terms of the contract, the total NPV to the initial payer over a defined time frame will be the same across all financial bond scenarios, irrespective of the conditions for payment. This amount depends on the bond’s coupon rate relative to the discount rate, and will equal:

- The hypothetical cost of the curative therapy if the interest rate on the principal is set equal to the discount rate (the example we modeled in Figure 6, using a hypothetical cost of cure of \$500,000)
- An amount greater than the hypothetical cost of cure if the bond coupon rate is greater than the discount rate, or
- An amount less than the hypothetical cost of cure if the bond coupon rate is less than the discount rate

Health Currency: Moving From Commercial Insurance to Medicare

One of the features of the health currency model is the ability of the initial payer to claim retrospective payment from the follow-on payer, as the follow-on payer enjoys the clinical benefits related to curative therapy. In our health currency example, we presented a scenario where a member transitioned from one commercial insurer to another commercial insurer. Figure 7 illustrates the cumulative clawback payment NPV for a member covered by a commercial insurer who moves to a non-commercial payer such as Medicare. In our example, entry into Medicare occurs in year 3, and Medicare payments are set at 50% of commercial payments (Congressional Budget Office 2017). We also assume in this example that Medicare is an absorptive state; that is, the member, once in Medicare, will remain so for the duration of the 10-year time frame. We contrast this Medicare scenario (yellow line) with the commercial scenario (blue line), assuming a 15% annual turnover and 10% clawback level.

Figure 7
Cumulative Clawback Payment NPV: Commercial and Medicare Scenarios



Interestingly, we note that the health currency in the Medicare scenario will provide a higher NPV payoff to the initial payer in the short term, despite Medicare payments being lower than commercial payments. This is due to the member’s aging into Medicare with full certainty (100% membership turnover). Over time, the cumulative probability that a member has moved to a new commercial payer in the commercial scenario will increase, enough to provide the initial payer with a greater total NPV clawback value than in the Medicare scenario. This is driven mostly by the higher payments in commercial insurance relative to Medicare.

Member Persistency and Loss Ratio

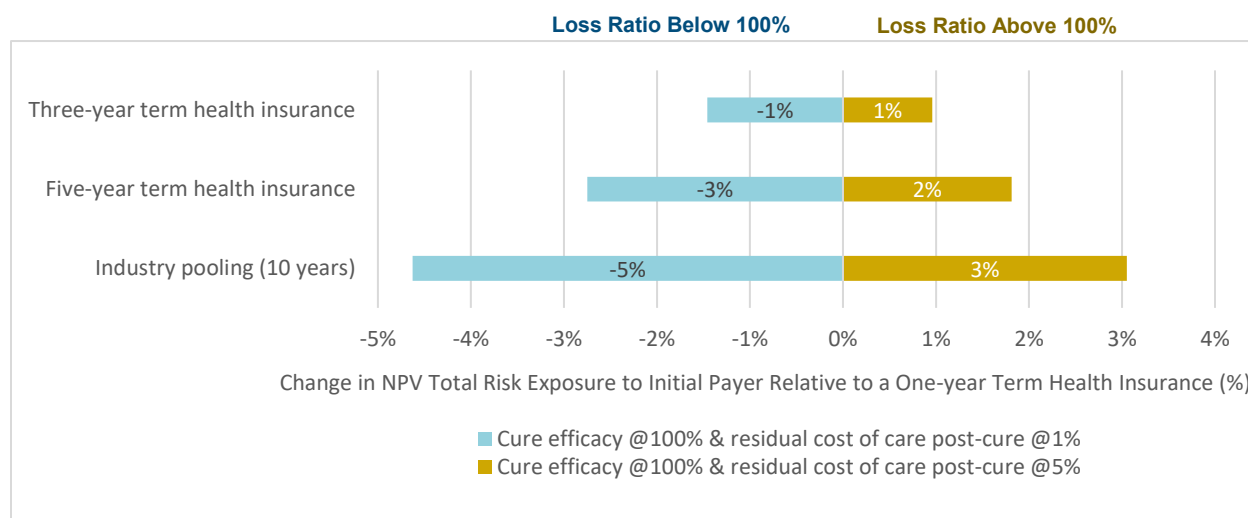
In our base case modeling for hemophilia, we assume the residual annual cost of care following the cure to be 5% of the pre-cure annual cost. Even at this low level, it is higher than the expected annual member premium.⁶ Therefore, even though the costs for the member have decreased substantially after treatment with the curative therapy, there is little financial incentive for the initial payer to retain this member, because expenses are likely to be greater than revenues. In other words, the post-cure loss ratio is expected to be greater than 100% in our modeling, even when the cure is achieved and sustained.

Figure 8 shows the percentage impact on the NPV total risk exposure to the initial payer over 10 years at varying member persistency (duration) levels, by comparing two scenarios:

1. Scenario with a post-cure loss ratio above 100%: 5% residual cost of care following the cure administration (base case)
2. Scenario with a post-cure loss ratio below 100%: 1% residual cost of care following the cure administration

The estimated change in NPV for the insurance-like models is benchmarked against the one-year term health insurance offering with 15% annual turnover. Overall, we note that models that further reduce member turnover by locking in a member for a longer duration will benefit the initial payer when the post-cure loss ratio is below 100%. Conversely, the impact on these same models will be negative when the post-cure loss ratio is greater than 100%, relative to the one-year term health insurance. Therefore, reducing member persistency, and ultimately mitigating the free-rider problem, may or may not increase the total future risk exposure to the initial payer. This will depend on the magnitude of the residual cost of care following the cure administration, in relation to premium revenue.

Figure 8
Expected Change to NPV Risk Exposure to Initial Payer at Various Durations



⁶ We assume that medical underwriting is not allowed.

Modeling Results: Cystic Fibrosis vs. Hemophilia

Similar to the example developed for hemophilia, modeling results are also presented for cystic fibrosis for the same payment models. The majority of observations relevant to hemophilia apply to cystic fibrosis, and potentially to other disease areas, too. While most of the modeling assumptions remain constant, the key difference is the annual cost of care in the pre-cure phase. In our modeling, the annual cost of care for members with cystic fibrosis is around one-fourth that of members with hemophilia. We also note that the mortality load is also disease-specific, yet its effect on the modeling results is limited.

Total Expected Financial Exposure to Initial Payer

In Figure 9, the total expected NPV of payments made by the initial payer is much lower in the cystic fibrosis example than in the hemophilia example shown previously. This is driven by the differences in the annual cost of care for patients who do not achieve or sustain the financial and clinical benefits of a curative therapy. The level of financial protection provided to the initial payer changes as we move from a very high-cost disease (hemophilia) to a more moderately expensive disease (cystic fibrosis). In other words, the magnitude of financial protection embedded in each of the payment models depends on the annual cost of care when no cure is available. We also note that the effectiveness guarantee of the annuity payment system and financial bonds produces a level of financial protection similar to what is offered by the health currency with a clawback level of 25%.

Figure 9
Total Expected NPV to Initial Payer: Cystic Fibrosis

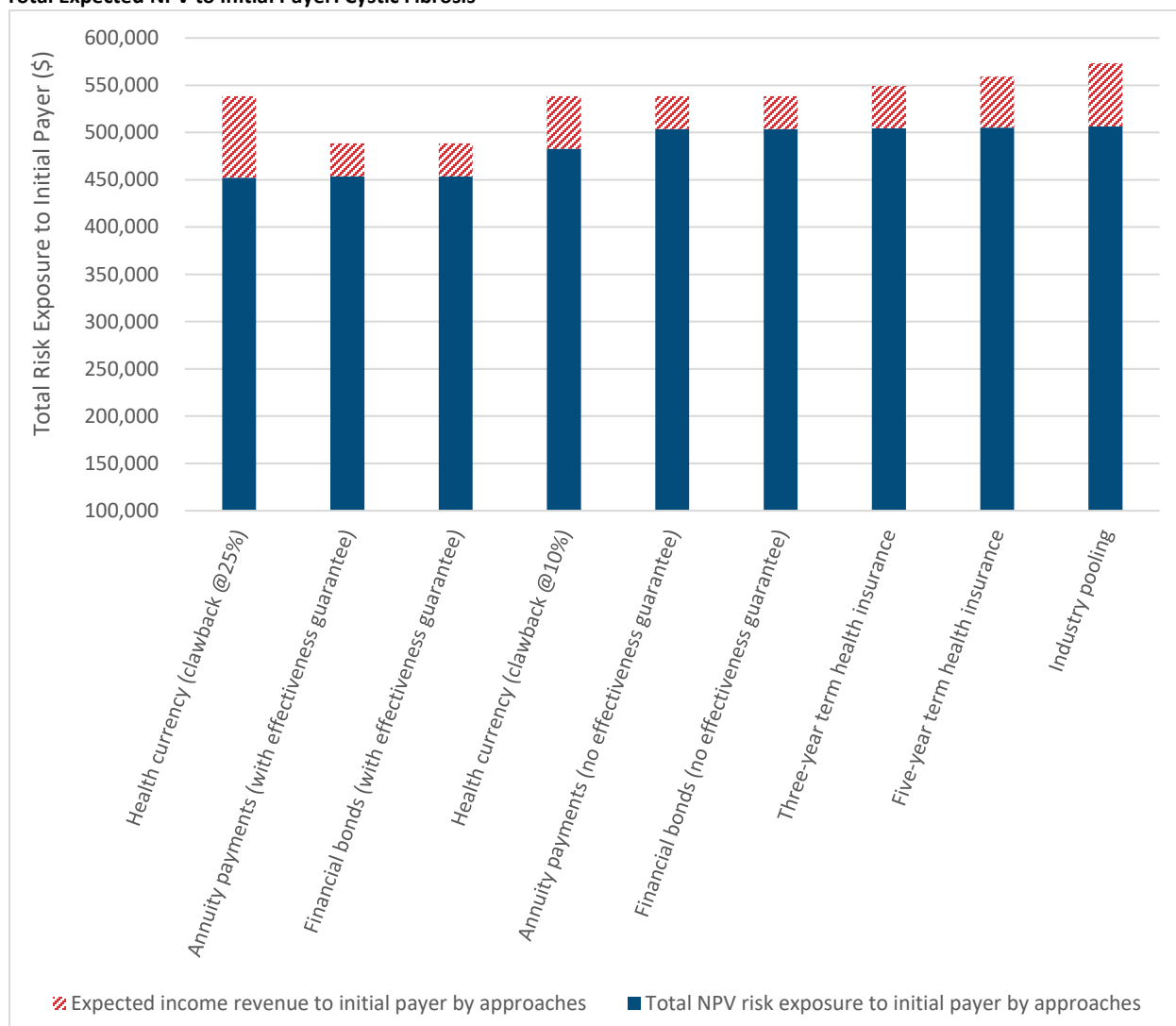
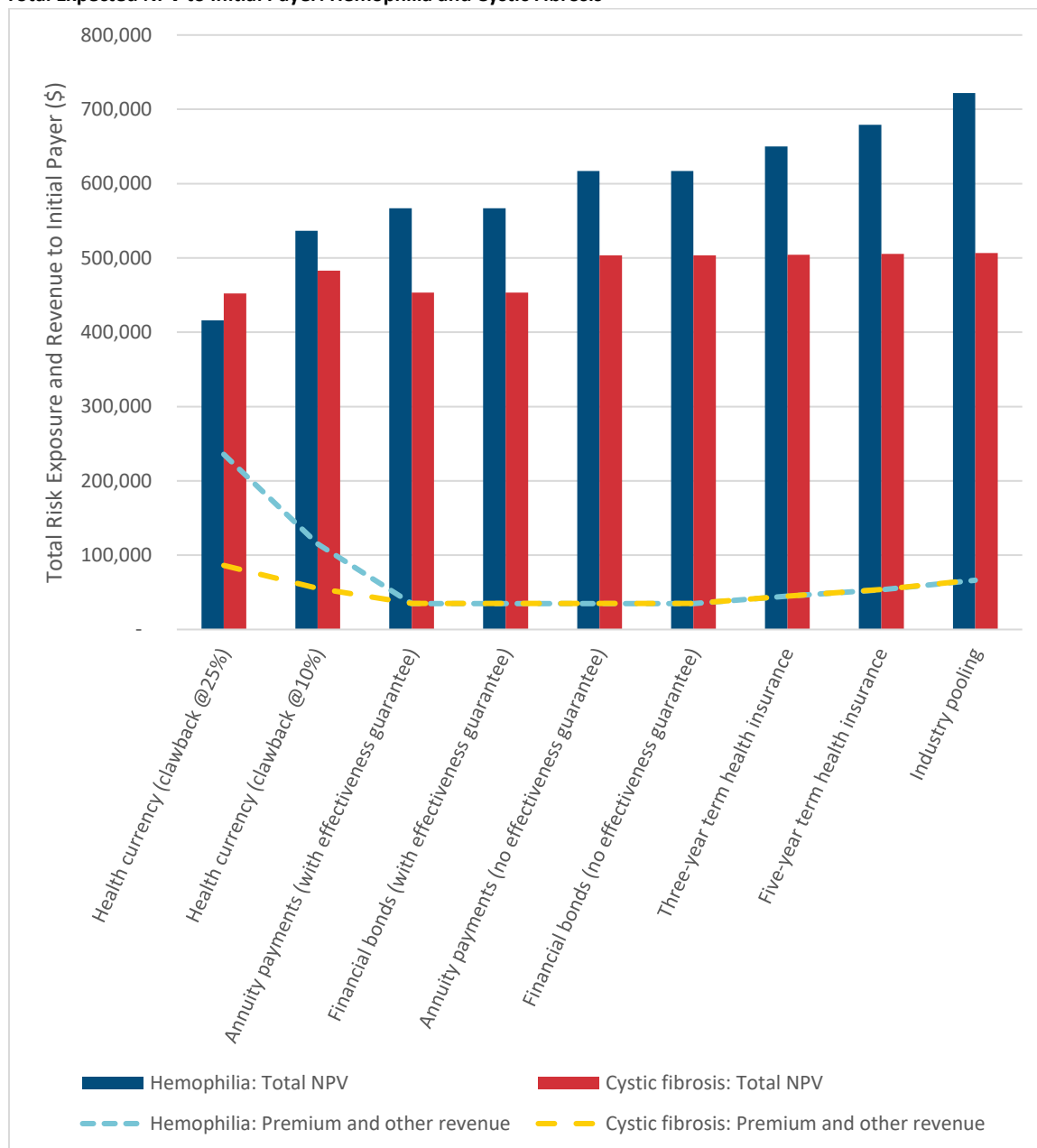


Figure 10 presents the total risk exposure and total revenue to the initial payer in the base case scenario for both disease areas. As discussed previously, the total clawback payment under the health currency model is considerably larger in the hemophilia example than it is in the cystic fibrosis example. The payment models producing the lowest and highest total risk exposure to the initial payer are the same in both disease areas. While the multiyear insurance and industry pooling still produce the highest total NPV, the gap between the NPV associated with these payment models and that of other payment models is considerably reduced as we move from a very high-cost disease to a moderate-cost disease. The multiyear insurance and industry pooling are positively affected by a lower residual cost of care following an effective curative therapy, because both approaches considerably reduce or eliminate membership turnover risk and therefore retain a given treated member longer.

Figure 10
Total Expected NPV to Initial Payer: Hemophilia and Cystic Fibrosis

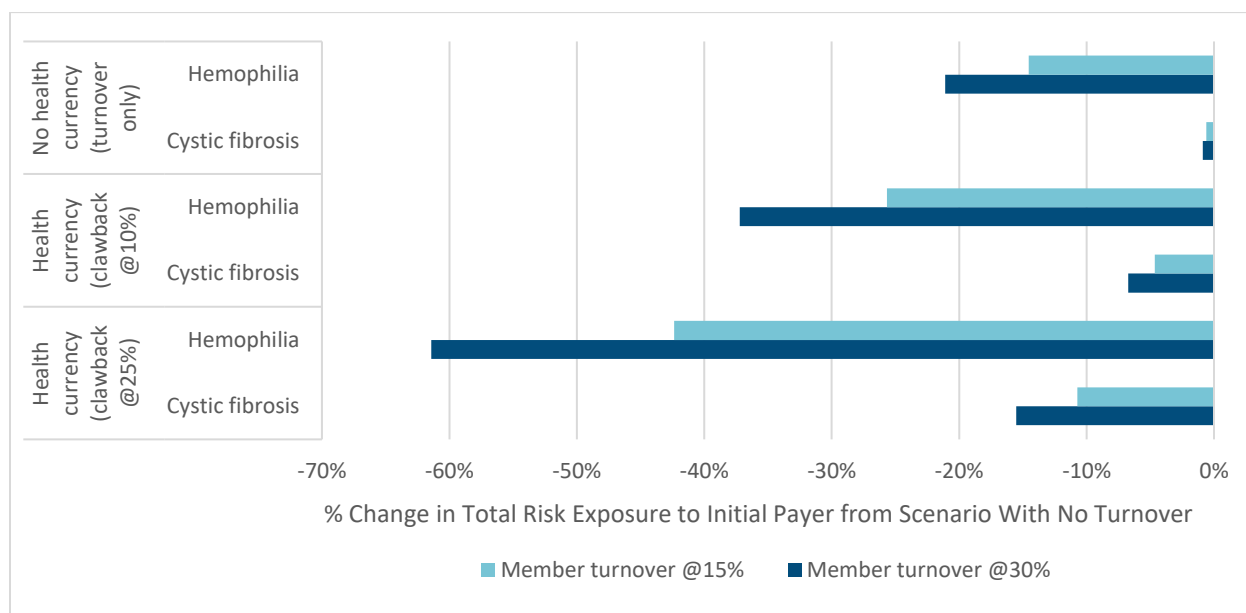


Note: The total risk exposure and total revenue to the initial payer for the two financial bond scenarios (with and without effectiveness guarantee) are identical to those under the annuity payment system.

Choosing a payment method like health currency to pay for a curative therapy seems to be more appropriate when there is a very large cost difference between the annual cost of care of members in the pre-cure and post-cure scenarios, and when turnover is high. In other words, the clawback feature of the health currency model is applied on a larger expected forgone savings value after the member leaves the initial payer’s books. Thus, the health currency model fares better in the hemophilia example than in the cystic fibrosis example, at a fixed turnover level of 15%, even if it still produces the lowest total risk exposure in both disease areas.

Figure 11 illustrates this observation and also highlights the impact on the total risk exposure to the initial payer of varying the annual turnover level over a 10-year period, from a scenario with no turnover. The two health currency scenarios are presented alongside a scenario where only turnover applies, for comparison. By definition, losing a member due to turnover will reduce the total risk exposure (compared with a no-turnover scenario), as the member is no longer on the initial payer’s books. Additionally, the magnitude of this reduction will be greater for (a) diseases that, like hemophilia, are on average more expensive to treat than diseases like cystic fibrosis and (b) models with higher clawback features.

Figure 11
Health Currency and Changes in Total NPV Risk Exposure to Initial Payer



Evaluation Grid: Summary

Designing a framework for evaluation enables assessing alternative payment models in a consistent manner. Summarizing the information from the preceding subsections, the proposed alternative payment models are assessed against the evaluation criteria to highlight the strengths and weaknesses of each approach. The modeling results informed the assessment of the payment models against the first four core criteria in Table 9. Our insights on the fifth criterion, barriers to implementation, are presented in the discussion of the report.

Table 9
Core-Criteria-Based Assessment of Payment Models

| Payment Models | Core Criteria | | | | |
|---|--|--|--|-----------------------------------|--------------------------------------|
| | Reduces Total Risk Exposure to Initial Payer | Reduces Efficacy Uncertainty About Value | Enables Risk Pooling at Population Level | Spreads or Delays Payment of Cure | Minimizes Barriers to Implementation |
| <u>Insurance-Like</u> | | | | | |
| Industry pooling | X | X | ✓ | X | ✓ |
| Multiyear insurance | X | X | X | X | ✓ |
| <u>Debt-Like</u> | | | | | |
| Annuity payments | ✓* | X | X | ✓ | X |
| Annuity payments with effectiveness guarantee | ✓* | ✓ | X | ✓ | X |
| Health currency | ✓ | X | X | X | X |
| Financial bonds | X** | X | X | ✓ | X |
| Financial bonds with effectiveness guarantee | ✓* | ✓ | X | ✓ | X |

*It is theoretically possible that selected conditions for payment or effectiveness guarantee reduce the total financial exposure to the initial payer; in practice, the manufacturer may decide to reflect this financial risk in the price of a curative therapy or to collect additional payments from follow-on payers. Yet we note that a payer may not value a given risk in the same way as a manufacturer or third-party entity.

**As discussed, the total risk exposure to the initial payer is reduced only where the bond coupon rate is smaller than the discount rate.

Overall, annuity-based systems can improve the long-term allocation of the cost of the curative therapy. The allocation of cost over time can also be paired with conditions for payment, ultimately providing an extra layer of protection to initial payers. Similarly, financial bonds do not require the cost of cure to be paid up front, as the full payment is due later—for example, at bond expiry. Annuity payments and financial bonds with effectiveness guarantees can reduce uncertainty around value, as well as total financial exposure. The health currency model represents the greatest opportunity for initial payers to reduce their total financial exposures to the cost of the curative therapy, yet the magnitude of the financial protection offered will vary depending on the clawback level. Note that health currency does not offer financial protection against the failure of the therapy. In practice, there may also be barriers to its implementation, particularly as members cross over to a different type of payer channel (i.e., commercial to Medicaid or Medicare).

Finally, Table 10 shows that the majority of the proposed payment models can be applied to both single- and multipayer systems. The allocation of the cost of curative therapy over time under the annuity payment model is likely to give rise to significant equity concerns in a single-payer system with an annual fixed budget. This is due to the commitment to pre-allocate funds for a particular disease area in an environment where budget allocation decisions are set each year. Further, the long-

term time frame required to evaluate the effectiveness and clinical duration of a curative therapy may render the outcomes-based annuity scheme challenging for payers in a multipayer system, because annual member turnover is a concern. The health currency and insurance-like approaches can reduce or mitigate the free-rider problem observed in multipayer systems.

Table 10
Payer-Specific Criteria-Based Assessment of Payment Models

| Payment Model | Criteria | | | |
|---|----------------------------------|---|--------------------------------|---|
| | Suitable to Single-Payer Systems | Maintains or Improves Equity Considerations | Suitable to Multipayer Systems | Reduces or Mitigates Free-Rider Problem |
| <u>Insurance-Like</u> | | | | |
| Industry pooling | √* | √ | √ | √ |
| Multiyear insurance | X | N/A | √ | √ |
| <u>Debt-Like</u> | | | | |
| Annuity payments | √ | X | √ | √** |
| Annuity payments with effectiveness guarantee | √ | X | √ | √** |
| Health currency | X | N/A | √ | √ |
| Financial bonds | √ | X | √ | X |
| Financial bonds with effectiveness guarantee | √ | X | √ | X |

*Single-payer systems are by definition a risk pooling mechanism.

**It is theoretically possible to reduce or mitigate the free-rider problem if payment ceases upon member turnover.

Discussion

Several sources of risk can arise within the context of high-cost curative technologies. The potential that a payer is unable to recoup most or all potential future financial benefits linked to a high-cost curative therapy is a major risk to a payer funding the therapy. All payers, both in the U.S. and in England, are exposed to the risk that the curative therapy is not effective or durable. Additional issues affect the categories of payers in the United States:

- The free-rider problem is a concern for commercial payers, especially regarding members who have a higher likelihood of leaving, such as children on their parents' plans (who age out by age 26) or an older adult soon to be eligible for Medicare. However, the largest commercial payers and self-insured employers have the capital to cover high-cost therapies for rare diseases, because few patients are receiving them, at least initially. Smaller insurers or employers are more likely to need an alternative payment mechanism, because the cost of treating even one or two members with a curative therapy could severely affect annual reserves and budgets.
- Medicaid has annual budget constraints due to state and federal funding. Similar to commercial payers, Medicaid also has a higher risk of turnover, especially because patients can move in and out of coverage throughout the year. Each state's program is unique, with varying eligibility and coverage criteria.
- Fee-for-service Medicare has less exposure to beneficiaries moving to another payer, but Medicare Advantage can experience higher patient turnover. Both fee-for-service Medicare and Medicare Advantage have greater risks of mortality than commercial or Medicaid payers, because nearly all beneficiaries are over the age of 65.

Other financial risks and considerations related to each alternative payment model may deserve attention, too. Notably, they include implementation of alternative payment models, financial reporting and clustering.

Implementation of Alternative Payment Models

A drawback of some of the proposed payment models is the long-term payment structure, which may add considerable administrative burden to payers and the partnering entities, particularly if patients are to be tracked and monitored over time to affirm that the curative therapy continues to be effective. In addition, health currency would also require financial settlements and retrospective payments at regular intervals. The use of a third party may be required, especially as members cross payer channels or move to payers with very different provider payment levels. Further, a reference or benchmark metric for the hypothetical cost of care and premium may be required for calculating the clawback payment. The health currency model also requires that a clawback percentage level be determined for a given disease area, and be applied uniformly across payers to ensure consistency.

A possible alternative to the health currency model is the annuity payment model. In fact, it could be possible to design an annuity scheme that could be passed on from one payer to the next as the member navigates through the system. Under this approach, a given payer would be responsible for making annuity payments only in the years that a member would be in the payer's book of business. The follow-on payer, and any subsequent ones, would therefore be responsible for the following streams of payment, until the next turnover point. This scheme would also address the free-rider problem.

An annuity-based payment model with outcomes-based guarantees could be implemented when a budget impact threshold is in place. Since April 2017, new health technologies assessed by the National Institute for Health and Care Excellence (NICE) in England are subject to new regulations, which include the introduction of a budget impact test (NICE 2017). The budget impact threshold in each of the first three years of a new technology becoming available for use may not exceed £20 million, or commercial negotiations will be triggered with the national health system. While it is possible to impose clinical restrictions on the use of a new technology to avoid exceeding the £20 million ceiling, the use of an annuity-based model has been proposed as a way to provide curative therapies to a greater number of patients each year (Jørgenson and Kefalas 2017), as only a fraction of the cost of curative therapy would be recognized in each year. Yet payment models that allow the amortization of cost over time are deferring cost into the future, thus potentially increasing the financial burden to the next generation by pre-allocating a proportion of future annual budgets. Similarly, we note that financial bonds would also delay the full repayment of the cost of cure (principal amount) to a date in the future (e.g., bond expiry), yet the total NPV to the initial payer may be

greater or less than the cost of cure as interest rates rise or decline in relation to the bond coupon rates. Therefore, this would represent an additional risk to payers if financial bonds are used as a way to pay for a curative therapy.

Regarding patient surveillance, it is possible, in theory at least, for the monitoring functions to be performed on a sample of patients in an effort to reduce the administrative burden. Yet the high variability of costs per patient, response heterogeneity, and the relatively low numbers of patients with a given rare disease may add some unintended complexity and credibility issues to this process. Single-payer systems may be better able to perform patient monitoring and risk-sharing agreements at an aggregate (population) level, therefore reducing the need to operate these agreements at individual levels.

Payment models like industry pooling, for example, could function at a disease area level, with payments cleared on an annual basis. For instance, insurers could form an industry pool (to act as the initial payer for the cure) to cover all costs related to a specific disease area in a given year. A compulsory risk pool would ensure participation from all, with contributions to the pool tied to insurer membership, for instance. Under this model, there would be no need for a retrospective payment mechanism between insurers, as the up-front cost of curative therapies would be shared among all participating payers. If the risk pool were voluntary, the free-rider problem would remain, because payers could choose to join or leave at any time.

We also explored the financial impact to the initial payer of implementing various policy contract lengths. Extending the contract duration, as with multiyear insurance, reduces the free-rider problem. Longer-duration contracts may increase the incentive to payers to provide services with clinical benefits expected to accrue and last over a longer period. Yet while the residual cost of care following a cure is likely to be materially reduced relative to the pre-cure phase, it is possible that the loss ratio of a member continues to be greater than 100%, post-cure. Therefore, mitigating the free-rider problem through longer insurance contracts may be at the expense of incurring additional residual costs that are higher than the premium revenue expected to be collected.

Finally, we discussed in the results section of the report the possibility of implementing various conditions for payment of the curative therapy to potentially reduce the total risk exposure. However, if the alternative payment arrangement is with the manufacturer, the manufacturer may factor these risks (e.g., turnover or efficacy) into the final cost of curative therapy. Regarding mortality risk, the issue of a patient dying from a cause unrelated to the curative treatment (e.g., accident) is rarely discussed. It would be theoretically possible to issue a term life insurance policy for a duration equal to the expected clinical benefits of the therapy to mitigate this risk to either the payer or the manufacturer. The lump sum policy amount would be set to the price of the curative therapy, with proceeds accruing back to the entity at risk within a predefined time frame. This approach would be relevant to both single-payer and multipayer systems.

Financial Reporting and Contract Adjudication

The purpose of an alternative payment model may be rooted in one or both of two concerns: (1) a need to mitigate a cash flow strain associated with a single high-cost event or (2) an improved allocation between expense recognition for a durable therapy and the period of clinical benefit. Specific to the U.S. health care system, there are financial reporting requirements that make it more difficult to accomplish the improved allocation than it is to alleviate cash flow strains. At least initially, the frequency of claims for curative therapies is likely to be very low for many payers, in part due to the prevalence of the disease states. However, as more therapies are approved, the aggregate exposure should increase, and the purpose of alternative payment models may come into sharper focus.

Finally, all of the debt-like payment models considered in this research will require a significant number of contractual parameters to determine the payments required at any point in time.

Variability, Clustering and Adverse Selection

Private payers are faced with another source of uncertainty: high variability in the number of patients due to clustering. The disease areas that we selected as illustrative examples are both rare genetic diseases. For private payers with smaller populations, the expected number of patients with a given rare disease is likely to be less than one (Fredericks et al. 2013). But due to the hereditary nature of rare genetic disorders, the expected value for the number of patients with a particular condition

may not represent the true exposure to payers, as family clustering distorts the distribution of prevalence among payers. While it may not be a concern for very large insurers, this uncertainty presents large financial risks to smaller payers. Industry pooling could mitigate this uncertainty in multipayer systems.

Industry pooling has its equivalent in single-payer systems. In England, there is a body that pays for all specialized services for a list of specified disease areas. This removes the financial risk of incurring large expenses from smaller regional bodies. This also removes the financial consequences of clustering. In the U.S. health care landscape, payers covering these curative therapies may experience adverse selection if other payers choose not to cover them. This may be particularly relevant for the individual market, if patients can choose among multiple insurers within the state. This could lead to further concentration of the insurer market as smaller insurers are not able to cover these technologies, with members eventually migrating to larger insurance players.

Beyond Rare Diseases

The illustrative scenarios presented focus on payment mechanisms for curative therapies for rare diseases. This is because rare diseases may be more likely to experience record-breaking prices for curative therapies, given the smaller treatment populations from which to recoup any investment from the creation of a new therapy. Yet we note that more prevalent disease areas may also benefit in future years from new developments in curative treatments, and that most, if not all, of the payment approaches explored in this report may still be valid in that context. The total budget impact of these new curative therapies in aggregate will, however, be of great concern to all payers alike.

Finally, the illustrative scenarios presented rely on disease areas where a standard of care or other treatment options are currently available to patients. Yet we note that some disease areas, in particular ultra-orphan diseases, may not have an existing treatment. Payment models that rely on the cost of existing care as a basis to establish any future clawback payments (as in the case of health currency) may not be as applicable in this context. However, the clinical benefits of a medical breakthrough for these populations with unmet medical needs would be enormous, so the need to develop and deploy alternative payment models may be even greater.

Appendix A: Drug Evaluation and Reimbursement in England and the U.S.

This appendix provides additional context about the factors driving a decision to pay or not pay for a cure. Our research and findings are based on the premise that an initial payer has already decided to provide a cure to a patient; we then analyze the various potential payment options. Consequently, this appendix is outside the scope of our research and is for informational purposes only.

England

Countries with a leading, recognized health technology appraisal body similar to NICE in England often rely on cost-effectiveness as the value determination framework when making a decision to fund or not fund a new drug or health technology. This is based on the premise that new technologies often will displace existing resources within the system, and while they may be more efficacious, they may also be more expensive than traditional treatments. NICE relies on a framework that assesses whether the incremental costs of a new technology over a comparator are worth the additional clinical benefits to patients. This is done using an external threshold or benchmark. In England, the threshold is informally set between £20,000 and £30,000 per quality-adjusted life year (QALY), although in practice, for some disease areas, it may be considerably higher. NICE often takes a long-term perspective in its evaluation, sometimes looking at a 30-year or even lifetime view to fully capture the costs and benefits of a new treatment. Technologies that NICE has appraised and recommended are required to be available for use within the following 90 days. It is the responsibility of regional NHS payers to provide the technologies to patients meeting the clinical specifications of the product. This unpredictability can sometimes create unexpected financial pressures at a local level, because budget allocations to regional NHS payers do not explicitly account for NICE funding mandates.

For this reason, more specialized services, which tend to be high-cost, low-frequency events, are normally paid for at a national rather than regional level. This pooling mechanism removes some of the financial risks associated with catastrophic events. Hemophilia and cystic fibrosis are two disease areas that fall within the remit of specialized commissioning in England.

U.S.

In the United States, there is no centralized evaluation process analogous to NICE. The Medicare program (Parts A and B) covers “medically necessary services . . . that meet accepted standards of medical practice” (CMS 2018b). The assessment of what is medically necessary cannot include an explicit recognition of cost (CMS 2018a). Private payers and the Medicaid program have greater flexibility in their decision making for whether and under what circumstances new technologies will be covered. As a result, access to new technologies varies and may require significant advocacy on the part of the patient or the provider (Rockoff 2018).

Developers of innovative therapies establish a “list price,” and there is no requirement to provide a justification for that price. However, the reimbursed cost may be negotiated downward or reduced by statute (e.g., Medicaid program). Notably, the Medicare program (Parts A and B) cannot negotiate the prices of drugs. Payers with relatively large books of business and/or strong reimbursement teams may be able to secure more favorable prices than smaller payers can. The reimbursement arrangements are not typically anchored on any mutually accepted value or cost-effectiveness analysis. One recent exception was the announcement that Regeneron would reduce the price of its cholesterol drug, Praluent, to the value determined by the Institute for Clinical and Economic Review (ICER) if certain coverage requirements were in place (Lovelace 2018).

Appendix B: Data Sources

We relied on U.S. paid claims data to understand the disease-related experience of patients with selected conditions over a one-year time frame. This is to better mirror the one-year contract period of most insurance policies. We extracted medical and pharmacy claims for commercial populations, as well as membership exposure data for the year 2015. The Milliman Consolidated Health Cost Guidelines™ Sources Database (CHSD) was used as the primary source of data. The CHSD data contains over 380 million member-months from commercial lines of business and is a consolidation of member experience data contributed by numerous health plans throughout the U.S. It contains claims information on commercial, Medicaid and Medicare payers. We also extracted similar claims for 2013 and 2014 to assess the consistency of the cost distribution over time for treating a particular condition and to inform payer-specific considerations.

Tables 11 and 12 provide descriptive statistics and paid cost distributions for the hemophilia and cystic fibrosis patient population identified in the 2015 commercial claims analysis (the values have not been extrapolated and are reflective of the sample size underlying the CHSD source).

Table 11
Descriptive Statistics

| Description | Hemophilia* | Cystic Fibrosis |
|----------------------------------|------------------------|------------------------|
| Total paid claims: Inpatient | \$6.7 million | \$28.6 million |
| Total paid claims: Outpatient | \$9.3 million | \$8.3 million |
| Total paid claims : Professional | \$66.8 million** | \$4.9 million |
| Total paid claims: Ancillary | \$15.3 million | \$4.6 million |
| Total paid claims: Pharmacy Rx | \$75.3 million** | \$69.0 million |
| Total of all paid claims | \$173.4 million | \$115.4 million |
| Total members / member-months | 1,073 / 12,876 | 2,614 / 31,368 |

* Hemophilia A and B, male population only.

** The majority of the paid claims cost from the professional category is for drugs provided in a professional (i.e., physician) setting. Together with the pharmacy Rx category, they account for over 80% of total paid claims cost.

Table 12
Annual Paid Cost Distribution

| Annual Paid Cost Distribution per Member | Hemophilia* | Cystic Fibrosis |
|--|-------------|-----------------|
| Mean | \$161,663 | \$44,169 |
| 75th percentile | \$185,976 | \$46,878 |
| 90th percentile | \$467,280 | \$128,942 |
| 95th percentile | \$684,176 | \$200,330 |
| Maximum | \$8,960,253 | \$2,678,157 |

*Hemophilia A and B, male population only.

Note on Membership Exposure

We report the medical and pharmacy actual paid claims cost at a member-line level. Only members with a full 12 months of medical and prescription drug insurance coverage are included in the scope. Consequently, we did not use any grossing-up factors to annualize costs. Excluding members with partial coverage during the year 2015 reduced the sample data size yet provided for a cleaner data set. Among the subpopulation groups excluded are members who have died during the year and newborns. We note that people in their very first or very last year of life may not necessarily be prime candidates for receiving a high-cost curative therapy. Similarly, payers may not necessarily be willing to offer members with partial and sporadic enrollment a one-off curative therapy.

Appendix C: Code Sets

We used a combination of ICD-9 codes (prior to October 1, 2015) and ICD-10 codes (after October 1, 2015) to identify and classify patients with selected disease areas. We considered medical costs only where the claim line was associated with an International Classification of Diseases (ICD) code for hemophilia (Table 13) or cystic fibrosis (Table 14). Therefore, we did not include all claims lines of members identified with either of the two conditions. This approach supports the idea that a curative therapy will not eliminate all medical costs of a given individual, but rather can reduce or eliminate the disease-related costs of a particular condition.

Table 13

Hemophilia Medical Codes

| ICD-9 CM | Description |
|-----------|--|
| 286.0 | Congenital factor VIII disorder (Hemophilia A) |
| 286.1 | Congenital factor IX disorder (Hemophilia B) |
| ICD-10 CM | Description |
| D66 | Hereditary factor VIII deficiency |
| D67 | Hereditary factor IX deficiency |

Table 14

Cystic Fibrosis Medical Codes

| ICD-9 CM | Description |
|-----------|--|
| 277.00 | Cystic fibrosis without mention meconium |
| 277.01 | Cystic fibrosis with meconium ileus |
| 277.02 | Cystic fibrosis with pulmonary manifestations |
| 277.03 | Cystic fibrosis with gastrointestinal manifestations |
| 277.09 | Cystic fibrosis with other manifestations |
| ICD-10 CM | Description |
| E84.0 | Cystic fibrosis with pulmonary manifestations |
| E84.1 | Cystic fibrosis with intestinal manifestations |
| E84.11 | Meconium ileus in cystic fibrosis |
| E84.19 | Cystic fibrosis with other intestinal manifestations |
| E84.8 | Cystic fibrosis with other manifestations |
| E84.9 | Cystic fibrosis, unspecified |

We further identified patients with the selected diseases by looking for relevant drug codes in pharmacy records, namely hematological agents and cystic fibrosis agents. For this, we used the U.S. Food and Drug Administration's National Drug Code (NDC) Directory. To be conservative, we counted only spending on drugs with codes specific to the two conditions and did not include pharmacy drugs that could also be used to treat other diseases or conditions, and which are nonexclusive to the two conditions analyzed.

Appendix D: Methodology and Model Assumptions

Table 15 summarizes the key assumptions and modeling inputs for hemophilia and cystic fibrosis in the base case scenario. Note that most assumptions apply to both conditions uniformly; only the annual cost of care (pre-cure scenario) and mortality load are disease-specific.

Table 15
Key Model Assumptions and Values

| Base Case Assumptions | Hemophilia | Cystic Fibrosis | Comments |
|--|------------|-----------------|--|
| Curative therapy efficacy | 90% | 90% | This is the hypothetical efficacy percentage of a curative therapy. It was set high under the assumption that payers would be unlikely to fund high-cost curative therapy if uncertainty around its efficacy was high. In the sensitivity analysis, we also explore efficacy of 70% and 100%. |
| Hypothetical cost of cure | \$500,000 | \$500,000 | This is the hypothetical price of the curative therapy, independent of the annual costs for treating patients with given conditions. In the sensitivity analysis, we explore 2 additional price points of \$250,000 and \$1 million for illustrative purposes. |
| Annual cost of care if no curative therapy | \$185,976 | \$46,878 | This is based on the 75th percentile of claims data that we extracted and represents the annual disease-related paid claims in 2015 for the U.S. commercial population that we looked at. In the sensitivity analysis, we also look at the impact of using the mean and the 90th percentile. Note that, for hemophilia, this represents the annual cost of care for the male population only.* |
| Residual cost of care following cure | 5% | 5% | This represents the hypothetical residual cost percentage assuming the efficacy of the curative therapy is achieved. We also tested 25% residual cost in the sensitivity analysis. |
| Discount rate | 3% | 3% | As some of the approaches amortize the cost of cure over time, we introduced a discount rate assumption of 3% but also tested the scenarios with no discounting. |
| Health care trend rate | 5% | 5% | This corresponds to the Milliman Medical Index™ (rounded up to the nearest percentage). In the sensitivity analysis, we also explored a 10% annual rate of increase for both claims and premiums. |
| Premium PMPY,** pre-cure | \$6,250 | \$6,250 | This is based on the average premium across all single coverage plans in the U.S., according to the 2015 Employer Health Benefits Survey done by the Kaiser Family Foundation. The year 2015 was set as the base year. |
| Premium PMPY,** post-cure | \$6,250 | \$6,250 | This was set to equal to the pre-cure premium per member per year. We assume no medical underwriting is allowed. |
| Clawback level | 10% | 10% | This applies solely to the health currency model and corresponds to the percentage of potential forgone savings that the initial payer would be entitled to claim back from follow-on payers. Two clawback levels of 10% and 25% are presented for illustrative purposes, but we acknowledge that other clawback percentages could be selected. |

| Base Case Assumptions | Hemophilia | Cystic Fibrosis | Comments |
|----------------------------|------------|-----------------|--|
| Annual membership turnover | 15% | 15% | This represents the membership turnover, or churn. In the sensitivity analysis, we also looked at scenarios with 0% and 30% turnover. |
| Mortality load | 250% | 1,000% | This corresponds to a mortality load applied onto the general population mortality rate and was based on literature review and is condition-specific. This helps to illustrate the impact of having different life expectancies between the 2 disease populations. |
| Coupon payment | 3% | 3% | This was set to the discount rate and corresponds to the annual coupon payment made by the payer to the third party. This assumption only applies to financial bonds. |
| Payer perspective | Commercial | Commercial | We adopted the perspective of the U.S. commercial population in our illustrative modeling. We note, however, that the Medicaid population was younger than the commercial population in the data sample we pulled. |

*Within the cystic fibrosis and hemophilia populations, we note that the distribution of the cost of care for these patients over a 1-year period varies widely and is highly skewed. Overall, diagnosed patients experience higher cost ranges than the average population, but it is difficult to predict expected costs for a given patient in any given year. Because curative therapies are a new treatment option with clinical uncertainties, it is likely that they will first be prescribed for patients who have the severest cases. For this reason, we decided to rely on the 75th percentile of the distribution of the annual cost of care (pre-cure) as input to the model.

**PMPY = per member per year.

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The SOA supports actuaries and advances knowledge through research and education. As part of its work, the SOA seeks to inform public policy development and public understanding through research. The SOA aspires to be a trusted source of objective, data-driven research and analysis with an actuarial perspective for its members, industry, policymakers and the public. This distinct perspective comes from the SOA as an association of actuaries, who have a rigorous formal education and direct experience as practitioners as they perform applied research. The SOA also welcomes the opportunity to partner with other organizations in our work where appropriate.

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Society of Actuaries
475 N. Martingale Road, Suite 600
Schaumburg, Illinois 60173
www.SOA.org