Attribution: Principles and Approaches

FINAL REPORT

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CONTENTS

EXECUTIVE SUMMARY

The United States has the highest per capita healthcare spending in the world, yet this high spending does not translate into uniformly better health outcomes for Americans. Performance measurement aims to address issues of quality and cost to improve health outcomes. Increasingly, performance measures are used for accountability purposes such as public reporting or value-based purchasing. Value-based purchasing is intended to link payment to improvements in healthcare quality, rather than simply paying for the volume of services rendered. National consensus-based performance measures are critical to support public reporting and value-based purchasing efforts because they provide the necessary information on quality and cost improvements. However, providing information about the quality of care to the public or reimbursing clinicians or providers for their performance on quality and cost outcomes requires understanding which patients and their subsequent outcomes a clinician or provider is accountable for. This can be challenging as healthcare continues to become increasingly team-based and patients often receive care from numerous clinicians and facilities.

Attribution is a process that aims to clarify these relationships and assign accountability for a patient's outcomes to a clinician, groups of clinicians, or a facility. The choice of an attribution model can affect which patients are included in the population addressed by a value-based purchasing program or included in the denominator of a performance measure. Differences in the populations included can result in meaningful differences in the cost and quality profiles for clinicians and facilities, affecting their reputation and reimbursement. However, attribution remains a relatively unstudied aspect of performance measurement.

In an effort to further explore these challenges, the National Quality Forum (NQF) convened a multistakeholder expert Committee and commissioned an environmental scan of current attribution models to define guiding principles, develop the Attribution Model Selection Guide for measure developers and program implementers, and develop a set of recommendations for the field.

Guiding Principles

The Committee agreed on a set of guiding principles to address attribution challenges:

1. Attribution models should fairly and accurately assign accountability.

2. Attribution models are an essential part of measure development, implementation, and policy and program design.

3. Considered choices among available data are fundamental in the design of an attribution model.

4. Attribution models should be regularly reviewed and updated.

5. Attribution models should be transparent and consistently applied.

6. Attribution models should align with the stated goals and purpose of the program.

THE ATTRIBUTION MODEL SELECTION GUIDE

What is the context and goal of the accountability program?	• What are the desired outcomes and results of the program? • Is the attribution model evidence-based? • Is the attribution model aspirational? • What is the accountability mechanism of the program? • Which entities will participate and act under the accountability program? • What are the potential consequences?
How do the measures relate to the context in which they are being used?	• What are the patient inclusion/exclusion criteria? • Does the model attribute enough individuals to draw fair conclusions?
Which units will be affected by the attribution model?	• Which units are eligible for the attribution model? • To what degree can the accountable unit influence the outcomes? • Do the units have sufficient sample size to aggregate measure results? • Are there multiple units to which this attribution model will be applied?
How is the attribution performed?	• What data are used? Do all parties have access to the data? • What are the qualifying events for attribution, and do those qualifying events accurately assign care to the right accountable unit? • What are the details of the algorithm used to assign responsibility? • Have multiple methodologies been considered for reliability? • What is the timing of the attribution computation?

Attribution Model Selection Guide

The Committee recognized that an important first step to evaluating attribution models is to determine the necessary elements of an attribution model that should be specified. The Attribution Model Selection Guide is intended to help measure developers, measure evaluation committees, and program implementers to specify the necessary elements of an attribution model. It represents the minimum elements that should be shared with the accountable entities and includes questions to answer in the development and selection of an attribution model. It is intended to improve standardization across attribution models and increase the ability to evaluate attribution models in the future.

Recommendations

The Committee's recommendations build on the guiding principles and the Attribution Model Selection Guide. They are intended to apply broadly to those developing, selecting, and implementing attribution models in the context of public- and private-sector accountability programs. The Committee's recommendations for selecting and implementing attribution models are:

1. Use the Attribution Model Selection Guide to evaluate the factors to consider in the choice of an attribution model.

2. Attribution models should be tested.

3. Attribution models should be subject to multistakeholder review.

4. Attribution models should attribute results to entities who can influence care and outcomes.

5. Attribution models used in mandatory public reporting or payment programs should meet minimum criteria.

INTRODUCTION

Improving quality while making care more affordable is a goal of all healthcare stakeholders. The reasons for reforming the healthcare system are well known: costs are high, quality can be poor, and care is often inefficient and uncoordinated. In a 2009 statement to the House Ways and Means Committee, the chair of the Medicare Payment Advisory Commission (MedPAC) noted that many of these problems are caused by the current fee-for-service payment system that rewards providing more care and creates a siloed approach to care delivery.[1]

Value-based purchasing, including alternative payment models, is widely seen as one potential solution to high healthcare spending. Value-based purchasing rewards clinicians or providers based on their performance on quality and cost measures. Critical to these programs is an accurate determination of the relationship between a patient and a clinician or provider to ensure that the correct entity or entities are held responsible for the patient's outcomes and costs. Determining which entity is responsible may be complicated given that most people receive care from numerous clinicians across several facilities. Attribution is a process that is intended to address this issue. Attribution is defined as the methodology used to assign patients, and their quality outcomes, to providers or clinicians.

Project Purpose, Scope, and Approach

The issues regarding attribution to accountable units such as clinicians and facilities have complicated the evaluation and implementation of performance measures. Measurement approaches need to recognize that multiple entities are involved in delivering care, and that these entities often have joint responsibility to improve quality. These issues have become increasingly important

Attribution is defined as the methodology used to assign patients, and their quality outcomes, to providers or clinicians.

in an environment of public reporting and value-based purchasing in which one entity may be held responsible for outcomes influenced by other clinicians and facilities.

The National Quality Forum (NQF), with funding from the Department of Health and Human Services (HHS) convened a multistakeholder Committee (Appendix A) to provide guidance to the field on selecting and implementing attribution models. The project involved:

1. a commissioned environmental scan of current approaches to attribution;

2. an analysis of the strengths and weakness of these approaches;

3. development of guiding principles for attribution; and

4. recommendations to guide the selection and implementation of attribution models.

NQF commissioned a team of researchers and clinicians to conduct an environmental scan of attribution models currently in use—and those that have been proposed but not implemented—and to write a paper to inform the Committee's deliberations on selecting and implementing attribution models in healthcare. The Committee identified attribution challenges and drafted a set of guiding principles to address the challenges. Building on these guiding principles, the Committee identified key questions and considerations in developing or selecting an attribution model, and made recommendations

to guide the selection and implementation of attribution models. The process of drafting consensus-based principles and recommendations was iterative (Appendix B) and incorporated Committee discussions from two in-person meetings, web meetings, and responses to public comments received on the draft principles and commissioned paper (Appendix C).

This report details the Committee's guiding principles, the Attribution Model Selection Guide, and recommendations for attribution models.

The Committee recognized that in some cases attribution can be applied in multiple ways within a single program. First, one attribution model is used to determine which patients are included in a program (e.g., Accountable Care Organization program) (Figure 1). Another attribution model is used to determine which patients are included for a performance measure that is used to determine the score that an accountable unit will receive for the program (e.g., diabetes quality measure) (Figure 2).

FIGURE 1. PROGRAM LEVEL ATTRIBUTION: This figure depicts patients being selected for inclusion in an accountability program through the application of an attribution model.
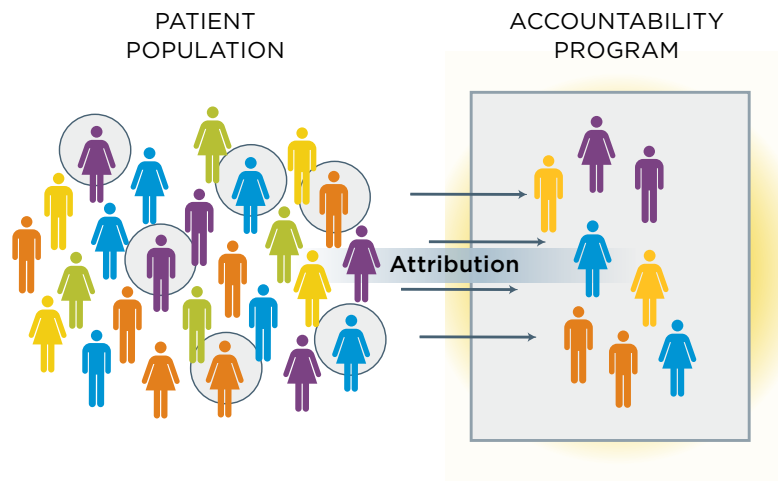
FIGURE 2. MEASURE LEVEL ATTRIBUTION: This figure depicts patients' costs, outcomes, and quality of care being attributed to various accountable units by applying an attribution model within each measure.
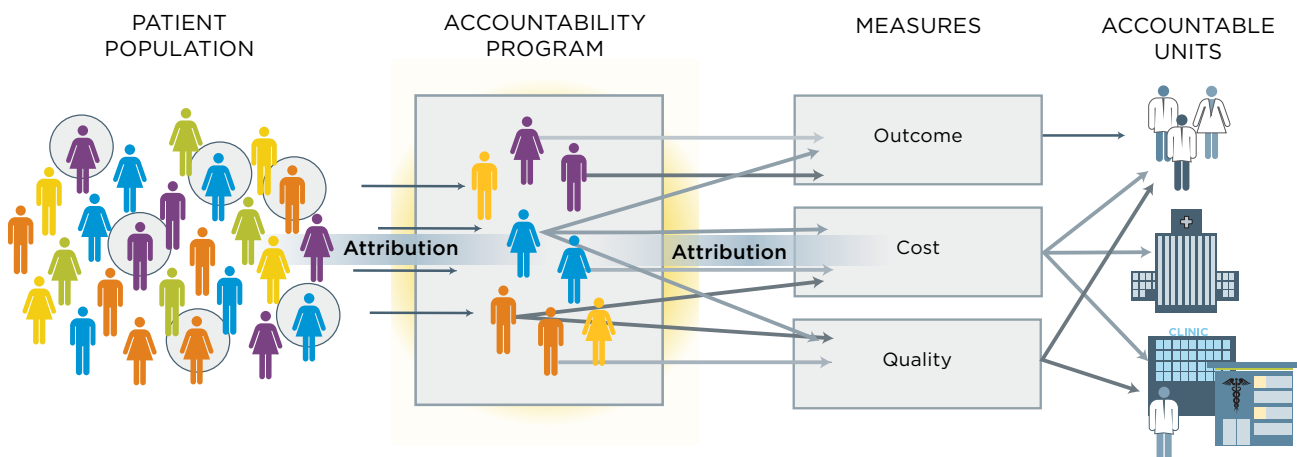
The Committee acknowledged that many stakeholders wanted the Committee to recommend a single attribution model or recommend specific attribution models for use in specific contexts. Unfortunately, there is insufficient evidence to support such guidance and recommendations at this time. As such, the Committee adopted a broad focus on attribution across a range of applications (quality measures, cost and resource use measures, and accountability programs), identifying areas of tension, key considerations, and where tradeoffs are required.

Definitions and Terminology

A glossary in **Appendix D** defines key terms used in this report. Definitions for five of these terms also appear below.

- **Accountable unit:** the entity whose performance is being measured, which could be a hospital, health plan, clinician, etc. Performance measurement can be applied to any setting and level of analysis.

- **Attribution**: The method used to determine which accountable unit is responsible for a patient's care and costs.

- **Attribution model:** An attribution model is a set of rules to define the accountable unit for a patient's healthcare outcomes.

- **Outcome:** The result of providing healthcare, broadly defined to include prevention and health promotion. The term, outcome, will be used to include the following types of outcomes relevant to performance measurement: quality outcomes of healthcare (e.g., mortality), intermediate clinical outcomes (e.g., BP < 140/90), patient-reported outcomes (e.g., depression), and economic outcomes of cost and resource use.

- **Quality of care**: This report considers quality broadly, based on a modified version of the Institute of Medicine's aims for healthcare: safety, timeliness, effectiveness, equity, and patient-centeredness.

Current Policy Landscape

Improving care delivery and quality continues to be a key focus for all healthcare stakeholders. Increasingly, there has been a focus on teamwork and a desire for performance measurement and reimbursement strategies that reflect this focus. Recent legislation, such as the Improving Medicare Post-Acute Care Transformation (IMPACT) Act of 2014 and the Medicare Access and CHIP Reauthorization Act (MACRA) of 2015, has increased the emphasis on person-centeredness and care coordination across providers.

As demonstrated by legislation such as IMPACT and MACRA, public- and private-sector payers as well as purchasers continue to look to value-based purchasing as a strategy to drive improvements in quality and cost while making the system more coordinated and person-centered by re-aligning incentives. Value-based purchasing aims to reward accountable units for meeting certain performance standards for quality and efficiency rather than paying for the volume of services provided. That is, these models aim to pay for performance. However, implementing pay-for-performance models requires a payer or purchaser to know which unit or units to hold responsible for the results of the quality and efficiency measures used to judge performance. This has become increasingly challenging as public and private payers move to assess quality based on outcome measures rather than process or structural measures.

The desire to move the system away from fee-for-service payment to alternative payment models has highlighted the need to better understand how patient outcomes and costs can be accurately attributed to a unit in a system increasingly built on shared accountability. In particular, the Department of Health and Human Services (HHS) has set a goal of tying 30 percent of traditional, or fee-for-service, Medicare payments to quality or value through alternative payment models, such as Accountable Care Organizations (ACOs) or bundled payment arrangements by the end of 2016, and tying 50 percent of payments to these

models by the end of 2018. HHS also set a goal of tying 85 percent of all traditional Medicare payments to quality or value by 2016 and 90 percent by 2018 through programs such as the Hospital Value-Based Purchasing and the Hospital Readmissions Reduction Programs.

HHS has developed a framework for categorizing payment models. Category 1 is fee-for-service (FFS) with no link between payment and quality. Category 2 is fee-for-service with a link between payment and results on quality measures. Category 3 includes alternative payment models built on the fee-for-service system. Finally, category 4 is population-based payment. Value-based purchasing includes payment models in categories two, three, and four. Accountability

for quality and cost as well as the focus on population health management increases through the categories. Increased use of these payment models makes the issue of attribution increasingly important and challenging.

Other efforts in the field have also attempted to review questions of attribution. In particular, the **Health Care Payment Learning & Action Network (LAN)** recently released a white paper exploring issues of attribution for population-based payment models (category 3 and 4). The LAN developed an attribution model that assigns populations to accountable units in a population-based payment model.[2] This work attempted to incorporate and build on the work of the LAN by also addressing models found in category 2.

TABLE 1. HHS PAYMENT MODEL TAXONOMY

	Category 1 FFS; no link of payment to quality	Category 2 FFS; link of payment to quality	Category 3 APMs built on FFS architecture	Category 4 Population-based payment
Description	Payment based on volume of services; no link to quality or efficiency	Payment varies based on quality or efficiency	Some payment linked to population or episode management. Payment triggered by delivery of service but opportunities for shared savings or risk	Volume not linked to payment. Providers are responsible for care of a beneficiary over time.
Medicare Examples	Limited in Medicare Fee for Service	• Hospital Value-Based Purchasing • Physician-Value Based Modifier • Hospital Readmissions Reduction Program	• Accountable Care Organizations (ACOs) • Medical homes • Comprehensive Primary Care Initiative • Comprehensive End Stage Renal Disease (ESRD) Model • Bundled Payments for Care Improvement (BPCI) Initiative	Eligible Pioneer ACOs in years 3-5

Attribution challenges have also arisen across NQF's work. Attribution concerns have been raised by NQF measure evaluation Standing Committees reviewing measures for NQF endorsement as well as by the Measure Applications Partnership workgroups considering measures for implementation in federal public reporting and value-based purchasing programs.

NQF endorses performance measures suited for both performance improvement and "accountability applications" (e.g., pay for performance, public reporting), when those measures meet a standard set of criteria using its Consensus Development Process (CDP). Committees of experts examine the importance, scientific acceptability, feasibility, and usability of performance measures. When examining the scientific acceptability of a measure (i.e., its reliability and validity), committees have questioned a measure's attribution model. This has been particularly challenging in the evaluation of cost and resource use, readmissions, and population health measures. Specifically, questions have focused on the locus of control of accountable entities when there is significant variability in the degree of care delivery fragmentation. Committees have also challenged the appropriateness of the selected accountable unit for a performance measure based on the measurement time period for which that accountable unit is responsible for a patient's outcomes.

The Measure Applications Partnership (MAP) convened by NQF provides input to CMS on the selection of measures for specific federal public reporting and payment programs through its annual pre-rulemaking process. Attribution concerns that have come out of this work include the application of measures in programs that do not align with the level of analysis or attribution approach specified in the measure. Additionally, measures are being used in payment programs that attribute outcomes to units that may be outside their direct locus of control (e.g.,

readmission rates, 30-day episode costs, and population health). The relationships between a hospital, the Hospital Value-Based Purchasing (VBP) Program and the Medicare Spending Per Beneficiary (MSPB) measure help illustrate these challenges.

Medicare bases a portion of hospital reimbursement on performance through the Hospital Value-Based Purchasing Program. Although the exact scoring algorithm is subject to change, measures are generally grouped into four domains: clinical care, patient and caregiver experience, efficiency and cost reduction, and safety. In fiscal year (FY) 2017 and beyond, the efficiency domain makes up 25 percent of a hospital's score. Currently, that domain only includes a measure of Medicare spending per beneficiary although additional measures have been recently finalized for future use. The MSPB episode spans the period three days prior to the index hospital admission through 30-days post-discharge. All events that occur during this period are included in the MSPB episode. This attribution method makes a hospital responsible for care (and costs incurred) in outpatient and post-acute settings and factors this into a hospital's reimbursement.

Key Findings from the Commissioned Paper

NQF commissioned an environmental scan and white paper to explore attribution models that are in use or have been proposed for use in the literature (Appendix F). The literature review found over 170 different attribution models that have been implemented or proposed. An important finding of this paper was the variability in approaches to attribution and the lack of rigorous evaluation of the methods used.

Several key findings from the commissioned paper informed the Committee's deliberations. First, the authors found that the quality measurement field has not yet determined best practices for attribution models, and many existing models

are largely based on approaches previously used. Second, the authors note that there are trade-offs in the development of attribution models that should be explored and made transparent. For example, there is a natural tension between the goals of reliability and validity of attribution models. Performance measures are more reliable and better able to distinguish performance across units when the sample size is larger. However, an attribution model that results in a larger sample for each unit may include patients that only received a small portion of their care from that accountable unit. The accuracy of the attribution model may be diminished in this case, thus emphasizing the need to balance attributing enough patients and attributing patients to the correct accountable unit. Finally, the authors noted that there is no standard definition of an attribution model.

The Committee recognized a number of current challenges to attribution. First, the Committee concluded that greater standardization among attribution models is needed to allow comparisons between models and for best practices to emerge. There is little consistency across models, but there is evidence that changing the attribution rules can alter results.[3] Currently there is often a lack of transparency on how care is attributed and no way for an accountable unit to appeal the results of an attribution model that may wrongly assign responsibility. Accountable units perceive a lack of control about which patients are attributed to them and their ability to influence those patients' outcomes. This has caused frustration and a sense of unfairness. To address these concerns, the Committee focused on developing principles, recommendations, and the Attribution Model Selection Guide to allow for greater standardization, transparency, and stakeholder buy-in with the aim of allowing evaluation of attribution models in the future and laying the groundwork to develop a more robust evidence base around this relatively unstudied measurement issue.

GUIDING PRINCIPLES

As a first step to addressing attribution challenges, the Committee agreed on a set of guiding principles to ground its recommendations. The principles acknowledge the complex, multidimensional challenges to implementing attribution models, as the models can change depending on their purpose and the data available. The Committee grounded its work in the goals of the National Quality Strategy: better care, healthy people/communities, and smarter spending. Attribution can play a critical role advancing these goals and driving improvement in the healthcare system.

Attribution can refer to both the attribution of patients to an accountable unit for accountability purposes such as a value-based purchasing program as well as the attribution of results of a performance measure such as health outcomes or resource use to an accountable unit.

The Committee highlighted the absence of a gold standard for designing or selecting an attribution model at this time. Therefore, it is important to understand the goals of attribution for each specific case when assessing potential attribution models to apply in particular situations. Key criteria to consider when selecting an attribution model are actionability, accuracy, fairness, and transparency. These criteria are particularly important, as the application of an attribution approach for performance measures can significantly influence measure reliability, validity, and results. Moreover, attribution can significantly affect the size of the population for whom accountable units are assigned responsibility as well as potentially determine their performance under value-based payment programs.

PRINCIPLE 1

Attribution models should fairly and accurately assign accountability.

The Committee recognized the need to identify a trusted patient/clinician relationship and enhance patient-centeredness and coordination of care in developing attribution models. However, it can be challenging to determine the patient/clinician relationship for purposes of performance measurement, particularly for outcomes where multiple clinicians or facilities may share responsibility. Not all healthcare can be delivered in the context of an established patient/clinician relationship, and there is a need to attribute acute or emergent events.

PRINCIPLE 2

Attribution models are an essential part of measure development, implementation, and policy and program design.

The Committee noted that in the past the way care or health outcomes were attributed did not receive sufficient attention. The choice of an attribution model should be among the primary concerns of both measure developers and program implementers since the attribution model can have a significant effect on performance measure scores or payment program results. A performance measure can be used with more than one attribution model, and measure implementers should carefully consider the downstream effects of the selected attribution model. For example,

There is a need to identify a trusted patient/clinician relationship and enhance patient-centeredness and coordination of care in developing attribution models.

attributing a measure to multiple accountable units rather than using exclusive attribution broadens accountability for patient care and could help improve care coordination, but this could also make it more challenging to take action on the measure results, if it is harder to pinpoint a quality problem.

Considered choices among available data are fundamental in the design of an attribution model.

Data plays an essential role in the implementation of an attribution model. Available data sources and data quality should be considered when designing and selecting an attribution model. Attribution models should leverage available data that are the most reliable and valid for their intended use. For example, the Committee discussed the attraction of using prospective patient-defined relationships for the purposes of attribution, yet the higher quality data may be claims data.

Data do not need to be limited to administrative claims, and the Committee recognized the importance of data from electronic health records as well as both patient- and clinician-reported data for attribution purposes. It is important to take into account new data sources as they become available. For example, the commissioned paper notes that while the exact attribution model varies among Pioneer ACOs, each involves some element of prospective attribution based on patient- or clinician-reported data. Physicians are provided a list of patients in their ACOs, and in some cases, ACOs may submit beneficiary attestations regarding their desire to be attributed to a certain clinician.

PRINCIPLE 4

Attribution models should be regularly reviewed and updated.

Attribution models should be regularly reviewed and updated as data availability and quality,

health system goals, and the evidence-base for attribution models evolve. The Committee acknowledged that best practices, care delivery systems, and the data available constantly evolve and that attribution models will need to change to improve and capitalize on this evolution. The Committee also noted that attribution models must be flexible in order to accommodate variations in the structure of healthcare delivery systems.

The Committee recognized that attribution models will need to evolve over time to support changes in policy, payment design, and measurement goals. As such, attribution models have to be judged within the context of the performance measure, payment program, patient population, and level of consequence of how the measure will be used. The Committee recognized the impact that temporal and environmental context can have on attribution models. The Committee noted that the time frame (e.g., the period of time during which services were delivered, the period of time the patient was an enrollee of a plan or an ACO, or the measurement period), the services included, the geographic context (e.g., rural or urban settings), the payment model, and the care delivery model can all significantly affect an attribution model and that a model should be revisited as these factors evolve.

PRINCIPLE 5

Attribution models should be transparent and consistently applied.

Currently, assignment of patients or outcomes to accountable units can be difficult to discern; often the details of the attribution model used are not available to the accountable unit. This lack of transparency may undermine the validity of such models because of perceived inaccuracies and lack of fairness.

Transparency is essential to accurate and fair attribution in both measure and program

applications. It is critical that the attribution for care and health outcomes be transparent to accountable units and patients. Details of the attribution model used and the data available must enable clinicians to know which patients' care or which portion of any particular patient's care they are responsible for. Timing is also critical, since it can allow accountable units to know and agree to their patient panel prospectively. This review of a patient panel can improve the fairness and accuracy of an attribution model and enable an adjudication process for potential errors in attribution.

Attribution models should align with the stated goals and purpose of the program.

The Committee acknowledged that performance measurement and value-based purchasing are mechanisms to drive improvement in the healthcare system by incentivizing behavior that leads to better health for patients and lower costs. However, policymakers and program implementers should be clear about the behavior they are trying

to incentivize by attributing health outcomes to a certain unit. Measure implementers should be aware that the attribution model selected will drive consequences, both intended and unintended. The Committee emphasized the risk of negative unintended consequences to patients and noted the need to ensure that attribution does not diminish access to care or detract from the patient-centeredness of care.

The selection and application of an attribution model should be accompanied by an explanation of the goals and purpose of measurement, the rationale used to identify the specific attribution methodology, and the intended/unintended consequences considered during the selection process.

Public comments generally supported the guiding principles. Commenters noted the need to distinguish the degree of responsibility for a patient's care and costs. Commenters also pointed out the need to balance the intended effect of catalyzing improvement with potential negative consequences. In particular, comments cautioned against attribution methodologies that could contribute to a lack of access to care.

ATTRIBUTION MODEL SELECTION GUIDE

The Committee recognized the current tension between the desire for clarity about an attribution model's fitness for purpose and the state of the science related to attribution. Stakeholders want rules to clarify which attribution model they should use in a given circumstance, but there is not enough evidence to support the development of such rules at this time.

As noted above, a significant finding of the commissioned paper was the current lack of a standard definition of the elements included in an attribution model. This lack of standardization across attribution models significantly limits the ability to evaluate the effectiveness of different approaches. An important first step to evaluating attribution models is to determine the necessary elements of an attribution model that should be specified. The Attribution Model Selection Guide is intended to help measure developers, measure evaluation Committees, and program implementers to specify the necessary elements of an attribution model. It should enable stakeholders to have a structured dialogue about attribution models and the decisions made when developing, selecting, or evaluating an attribution model.

The Attribution Model Selection Guide represents the minimum elements that should be shared with the accountable entities (Table 2). The details of an attribution model, and the choices made in developing the model, should be transparent to patients, accountable entities, and other stakeholders. An attribution model must be well-defined and precisely specified, with adequate testing, so that it can be implemented consistently. The Attribution Model Selection Guide includes a series of key questions to answer in the development and selection of an attribution model. It is intended to improve standardization across attribution models and increase the ability to evaluate attribution models in the future.

Measure developers and program implementers should use the Attribution Model Selection Guide when implementing an attribution model in a measure or program. The Guide articulates strengths and weaknesses of different approaches, as it walks the user through questions to consider. Users should consider these factors and the trade-offs involved as they select an attribution model.

TABLE 2. THE ATTRIBUTION MODEL SELECTION GUIDE

What is the context and goal of the accountability program?	• What are the desired outcomes and results of the program? • Is the attribution model evidence-based? • Is the attribution model aspirational? • What is the accountability mechanism of the program? • Which entities will participate and act under the accountability program? • What are the potential consequences?
How do the measures relate to the context in which they are being used?	• What are the patient inclusion/exclusion criteria? • Does the model attribute enough individuals to draw fair conclusions?
Which units will be affected by the attribution model?	• Which units are eligible for the attribution model? • To what degree can the accountable unit influence the outcomes? • Do the units have sufficient sample size to aggregate measure results? • Are there multiple units to which this attribution model will be applied?
How is the attribution performed?	• What data are used? Do all parties have access to the data? • What are the qualifying events for attribution, and do those qualifying events accurately assign care to the right accountable unit? • What are the details of the algorithm used to assign responsibility? • Have multiple methodologies been considered for reliability? • What is the timing of the attribution computation?

What is the context and goal of the accountability program?

Attribution models must be evaluated in the specific program context for which they are intended and take into account the context and goal of the program, the accountability mechanism used (e.g., payment or public reporting), and the intended behavior change. An attribution model must align with these three elements, since an attribution model that works in one program context may not work for another. Finally, the attribution model should advance the National Quality Strategy by improving care and outcomes for patients or making care more affordable.

What are the desired outcomes and results of the program?

The Committee's discussion highlighted the need to understand the goals of attribution when assessing potential attribution models. Attribution is a powerful tool to increase accountability for outcomes. Tying outcomes to an accountable unit's reimbursement through a payment program or reputation through public reporting can catalyze improvement. Accountability programs are designed to foster specific improvement goals. The Merit-Based Incentive Payment System (MIPS) reimburses clinicians based on quality, resource use, clinical practice improvement activities, and meaningful use of certified EHR technology. The Hospital-Acquired Condition Reduction Program requires payment reductions based on rates of specific hospital-acquired conditions. An attribution model must support the outcomes that a program is trying to improve and tie the correct outcomes to the correct units.

Is the attribution model evidence-based?

Attribution is a powerful tool to increase accountability for outcomes. Evidence should show that the accountable unit can influence the outcome. The Committee recognized that attribution is an evolving science; however, it also asserted that there should be evidence that the accountable unit can influence the results by modifying underlying processes or structures.

Is the attribution model aspirational?

While some accountability programs (i.e., payment or public reporting programs) are designed to speed uptake of evidence-based care practices already in use, others are designed to incentivize fundamental shifts in how units understand and act on their responsibility for patient outcomes. The changes envisioned may reflect aspirations for health systems and care providers to better coordinate care. Such programs are not inherently good or bad, but in an aspirational program, the attribution model is central and should be fully vetted. The intended behavior change should be fully transparent and understood; the attribution strategy should align with the desired change in behavior; and the outcome measure's use should be fair to the accountable unit.

Attribution of a population outcome such as county smoking rates to particular providers, such as hospitals, exemplifies aspirational use of an attribution model. (MAP reviewed a measure meeting this description in 2015-2016 pre-rulemaking.) Attributing county smoking rates to hospitals would assign hospitals a new responsibility and incentivize them to act to lower rates among the many people in their community who never seek hospital care. The attribution of this measure to a hospital program would clearly be aspirational, as it would attribute the outcomes of many people who were never seen at hospital. It might be acceptable to patients, program implementers, and the accountable unit if expectations were clearly defined, if there were interventions that the accountable unit could take (e.g., advocating for higher cigarette taxes, funding quit lines, making nicotine replacement more accessible), and if rewards or penalties were commensurate with the uncertain results. If aspirational programs achieve results, they generate evidence and gain acceptance over time (e.g., attribution of 30-day readmissions to

hospitals; Maryland's population-based global hospital budget). As Ryan, et al., note, however, it can be challenging to develop attribution models for this purpose while being responsive to concerns about achievability.[4] Hence, it is important to consider explicitly the degree to which an attribution model is aspirational and guide its design and use accordingly.

What is the accountability mechanism of the program?

Attribution models used in payment, public reporting, or network design programs require a greater degree of accuracy than those used for quality improvement. An attribution model used for payment, public reporting, or network design can affect an accountable unit's reimbursement and reputation. This creates a tension between the desire for improvement shared by all stakeholders and the need to ensure that a model is holding the right unit accountable.

Specifically, the Committee discussed a tension between a desire to try new approaches to attribution that may not have had rigorous testing and to be fair to clinicians and facilities as to who is being held accountable for what. The tolerance of error or inaccuracy in the data, measurement, or attribution results may be higher for quality improvement applications and lower when attribution models are being used for accountability applications, such as payment and public reporting. The degree of tolerance for error may also depend on whether provider participation in the accountability programs is voluntary or mandatory. When clinicians or facilities are subject to mandatory accountability programs, greater accuracy in the data supporting the attribution model and attribution results may be needed.

Which entities will participate and act under the accountability program?

Accountability programs may target different levels of the healthcare system. Some programs

such as the Medicare Shared Savings Program assess quality at the ACO level. Others, such as the Hospital Readmissions Reduction Program, assess an individual hospital, while MIPS could assess an individual clinician or a group of clinicians. An attribution model should align with how the program assesses quality and the goals it is trying to achieve while recognizing the locus of control of each unit.

What are the potential consequences?

The Committee emphasized that attribution models can have consequences, both intended and unintended. The potential consequences of an attribution model should be identified and considered. In particular, the potential negative implications for patients should be identified and mitigated. The Committee had concerns that vulnerable and complex patients may be avoided, and it recommended the use of safeguards such as proper risk adjustment and outlier exclusions.

Feedback from commenters noted that measures and incentives may have the intended effect of catalyzing improvement, but may also have unintended effects. Commenters cautioned about the potential for attribution to take resources away from underserved areas if clinicians and providers are held accountable for outcomes that are outside their control.

How do the measures relate to the context in which they are being used?

The Committee recognized that attribution happens at both the program and measure levels. An accountability program will likely only reflect a subset of a unit's patients, and an attribution model is needed to determine which patients attributed to the accountable unit by the program will be included in the results of each quality or cost measure in the program. For example, the measures included in the Hospital Readmissions Reduction Program would only reflect Medicare beneficiaries with certain conditions. A hospital's

measure results would not reflect patients without these conditions.

Likewise, each measure within a program has an attribution model within it that attributes the measure outcome for the included population to the accountable unit. It is critical to have alignment between the accountability mechanism, goal of the program, measures being used, and ability of the accountable unit to influence the outcome.

What are the patient inclusion/exclusion criteria?

The Committee emphasized the need to ensure that the outcomes addressed by the measures in the program are driving towards the ultimate improvement goal. The Committee reiterated its focus on attribution for accountability purposes and recommended that measures being used for such purposes have an appropriate degree of scientific rigor. In particular, there should be accurate data to support the measure and the attribution of its results.

The Committee recognized the importance of ensuring fair comparisons between units and recommended that measures used for accountability purposes be appropriately risk-adjusted and have adequate exclusion criteria to ensure outlier management. Such outlier management is essential to remove randomness from the sample that could lead to incorrect inferences about a unit's performance, especially when the results of a measure are being used for accountability purposes.[5] For example, the Committee recognized that a unit may see a complicated case that requires a higher level of care to ensure a positive outcome, which could have a significant negative impact on how the unit performs on resource use measures.

The Committee looked to the work of the NQF Consensus Development Process (CDP) to ensure the scientific acceptability of performance measures.

Does the model attribute enough individuals to draw fair conclusions?

Accurate measurement depends on having a large enough sample size for results to be meaningful. An attribution model must include enough individuals to draw fair conclusions while appropriately excluding outliers and employing proper risk adjustment to compare the performance of attributed entities accurately. The Committee recognized that performance measures employ exclusion criteria and risk adjustment within the measure but emphasized that there must be alignment between the specifications of the measure and the program. An attribution model may require its own rules outside of the measures being used to ensure fair comparisons. The Committee noted that attributing enough individuals to draw fair conclusions is a particular concern for rural clinicians or providers or other entities facing issues with small numbers.

The Committee recognized that the reliability of a measure depends on an adequate sample size, and some measures may have groups of providers that do not have enough cases for a reliable measure score. The Committee recommended avoiding the rating of specific accountable units with an inadequate denominator rather than not using a measure because some units may have small sample sizes.

Which units will be affected by the attribution model?

Increasingly, healthcare is being provided in a team-based environment, making it important to attribute results to the right players. Attribution is a tool to create groups for comparison. An attribution model should identify who is expected to take action based on the goals and purpose of the program or measure balanced with the ability of the accountable unit to influence the measure result.

Which units are eligible for the attribution model?

Attribution models can assign accountability to individual clinicians, groups of clinicians, facilities, or ACOs. The goal of the attribution model should define its breadth, as some circumstance may require attributing results to individual clinicians, while others favor greater aggregation. While the greater number of patients that can be assigned to larger entities can improve the reliability of a measure, this must be balanced with the actionability of results. Models that assign accountability to smaller units may allow for more ability to pinpoint where specific improvements are needed. The Committee emphasized that entities eligible to receive attribution must be able to meaningfully influence the outcomes of the patients they are being held accountable for.

Attribution models that assign patients to clinicians may also specify what types of clinicians those patients are attributed to. The Committee recognized the particular challenges that attribution to certain types of clinicians may entail. Many attribution models depend on attribution to a primary care provider (PCP). However, clinicians other than those who are considered to be PCPs may provide primary care. For some chronic conditions, a specialist may drive the care plan, or the patients may consider a specialist to be the PCP. Attribution to a specialist involves challenges including scope of practice and holding a specialist responsible for outcomes well beyond what he or she can meaningfully influence.

The Committee stressed that measures used in an accountability program must be tested at the level of analysis of that program. Measures, and measure concepts, may be taken from one program where they were attributed to one accountable unit or set of entities and used in different programs. When a measure is adapted for new program contexts or different accountable units, the attribution model must be tested at the level for which it is being proposed or used. The Committee noted that it is essential to consider

whether the measure performs adequately in this new context before it is used to evaluate the performance of an accountable unit.

To what degree can the accountable unit influence the outcomes?

Accountable units receiving attribution should be able to influence the outcomes they are being held accountable for. The Committee recommended that accountability applications (e.g., public reporting, payment, network design) may require more certainty that the accountable unit can influence the results compared to quality improvement programs. Attribution models can help drive progress towards aspirational goals such as improved care coordination, and the Committee noted the desire to use attribution to incentivize behavior change. For example, the Committee noted that holding hospitals accountable for 30-day readmission rates could incentivize them to improve care coordination and ensure that they are working with high-quality post-acute care partners. However, attribution models should identify accountable entities that are able to meaningfully affect measured outcomes directly or through collaboration with partners whom they can reliably influence.

Do the units have sufficient sample size to aggregate measure results?

The Committee discussed the need to be transparent about the minimum sample size needed to support the attribution model and measure computation. Performance measures have greater reliability when a large number of patients are attributed to accountable entities. While this increases the ability to distinguish performance across clinicians or facilities, it risks including patients that may have received the majority of their care from a different clinician or facility and compromises the validity of the attribution model. Increasing the validity of the attribution model may result in leaving out some patients or cases.

Engaging patients can improve data about what care was provided for them and help provide a more complete picture of the relationship. Clinician attestation would allow clinicians and providers an opportunity to confirm the relationship as well.

In order to compare the performance of attribution entities fairly, an adequate sample size is needed to achieve sufficient rigor in the measure computation, with outliers excluded and/or risk adjustment performed. In some cases, however, it may not be possible to achieve an adequate sample size. For example, small group practices and small rural and urban hospitals with lower patient volumes—where there may be fewer clinicians with a larger scope of services—will still require attribution and attribution models. These "nonperfect" cases, in which adequate sample size or accurate data is lacking, are a reality of our diverse healthcare system, and these cases require consideration when developing and selecting an attribution model.

Are there multiple units to which this attribution model will be applied?

Attribution models may attribute patients to one accountable unit or multiple accountable units. The authors of the commissioned paper found that the majority of current models only attributed to a single unit but noted that attribution to a single unit may not recognize the role that other units play in a person's care. Attribution to multiple entities may help to foster shared accountability and recognizes that multiple units may contribute to the care a person receives. Future models should consider ways to attribute to multiple units in ways that are proportional to their involvement, such as weighting schemes. Public comments suggested that rather than proportional weighting, programs should focus on a defined set of "proximal outcomes" that are specific to each type of accountable unit but contribute to the achievement of a larger aspirational goal. The Committee expressed a desire that future models will better reflect an accountable unit's scope of practice and locus of control.

How is the attribution performed?

There are varying attribution methods currently performed, and there is a lack of objective evidence to recommend one approach over another. The questions in this section represent key considerations that should be taken into account when developing an attribution methodology. The Committee emphasized that the methodology must be developed to fit the context of its use. A methodology that works for a quality improvement program may not work for an accountability application. The attribution methodology should help drive the goal of measurement but must take into account the clinical circumstances, an accountable unit's ability to affect the measured outcomes, and scientific rigor.

What data are used? Do all parties have access to the data?

The Committee reiterated the guiding principle that data availability and quality are fundamental to the design of an attribution model and recommended using the most accurate and timely data possible. An attribution model must demonstrate sufficiently accurate data sources to support the model in fairly attributing patients to accountable entities.

Ryan, et al., found that medical claims are the most commonly used data source for current attribution models.[6] The Committee recognized the potential advantages of claims data such as accessibility and larger sample sizes. However, the Committee reiterated that data do not need to be limited to administrative claims and encouraged the continued development of alternative data sources that would support more accurate and timely attribution models. The Committee recognized the promise of data from electronic health records

(EHRs) but noted some current limits of this data, such as data blocking, inability to access records from other organizations, and lack of interoperability.

The Committee acknowledged the current desire to move to patient attestation as a data source for attribution models. While patient attestation can advance a more person-centered system, there are concerns about this data, including data collection burden, accuracy, and availability. Engaging patients can improve data about what care was provided for them and help provide a more complete picture of the relationship. Clinician attestation would allow clinicians and providers an opportunity to confirm the relationship as well.

Finally, the Committee recognized promising new data sources that could improve attribution, such as the development of the CMS patient relationship codes and categories required by MACRA, increased use of the National Provider Identifier, and integration of registry data.

What are the qualifying events for attribution, and do those qualifying events accurately assign care to the right accountable unit?

The scan of current approaches found potential events that are used to trigger attribution. Visits and spending were the two most common approaches. The authors noted some key considerations around each approach. They noted that visits can differ depending on the purpose and the services provided, while spending could lead to increased attribution to specialists who may have limited involvement in the clinical decisions that lead to that spending.

What are the details of the algorithm used to assign responsibility?

An attribution model is based on a series of rules used to determine accountability. The Committee recognized that current attribution models use different algorithms to assign responsibility. The algorithm could be based on attestation, assigning accountability to the unit identified

by the patient. As noted above, the Committee commended the patient-centeredness of this approach but cautioned that this must be balanced with accuracy of the data provided as patients may see multiple clinicians, change health plans or primary care providers over the course of the measurement period, or may attribute to a clinician who may not have had control over the majority of their care. The Committee did note that patient and clinician attestation can help to verify the relationship and ensure that the attribution model reflects the care provided. Prospective approaches can also help a unit to understand which patients they are responsible for in advance and work with those patients proactively to manage their health—a significant potential positive for a population-based payment model.

The Committee recognized that claims-based approaches have the benefit of reflecting the care that was actually provided. Ryan, et al., found a number of claims-based approaches in the environmental scan. An algorithm based on plurality may assign accountability to the clinician with the greatest number of a patient's evaluation and management (E&M) visits.[7] One study found that this approach allowed for the greatest number of patients and their visits to be counted.[8] However, the Committee cautioned that this approach can have significant drawbacks and could lead to a clinician being attributed an entire episode when that clinician had only limited interaction with the patient. For example, if a person were hospitalized for congestive heart failure and suffered an adverse drug reaction during a hospital stay that presented as a severe rash and required a consultation and follow-up care from a dermatologist, that dermatologist may end up billing the greatest number of E&M visits. This approach would attribute all responsibility for the patient's costs and outcomes to the dermatologist. The Committee noted that the desire to attribute highest number of patients must be balanced with what is in a unit's control and the actual clinical circumstances.

Other retrospective claims-based approaches include a majority approach, which might attribute responsibility to the clinician who billed greater than 50 percent of E&M visits. This stricter approach may help prevent attributing patients to a clinician who has limited interaction with them but may result in a smaller sample and could affect reliability. Ryan, et al., also noted that this approach could exclude some patients with whom the clinician does have a relationship.[9]

Other approaches may attribute responsibility to multiple units. These include a "one-touch" rule, attributing the patient to anyone who provided care, or a multiple approach, attributing the patient to all clinicians billing more than a certain percentage of E&M visits. These approaches could help to foster shared accountability but could also result in less specificity, making results less actionable.

Have multiple methodologies been considered for reliability?

The Committee stressed the need to use transparent, clearly articulated, reproducible methods of attribution. Currently, little information is available about the reliability testing of attribution models, and the choice of attribution model can have a significant impact on the measure or program score. The Committee recommended that multiple methodologies be tested and compared to see how the results would differ. One study of physician cost profiles found significant variation in which episodes could be attributed to a physician based on the attribution methodology selected (range 20 to 69 percent).[10] The work also found that compared to a default rule, 17 to 61 percent of physicians would be assigned to a different cost category when a different methodology was used. Program implementers and measure developers should choose a reliable approach that aligns with the improvement goals they are trying to achieve.

The Committee recognized the desire for greater guidance around what methods of reliability testing could be used and what acceptable standards of reliability could be. The Committee noted the need for future work to determine appropriate

testing of an attribution model. The Committee also noted the need to determine appropriate ways to test the validity of an attribution model. As a first step, the Committee stressed the importance of transparency of the attribution algorithm and how results are calculated.

What is the timing of the attribution computation?

The Committee stressed the importance of timing in an attribution model and noted that there are multiple relevant time periods that should be considered: one for performing the attribution and then the measurement period during which outcomes are tracked.

First, the Committee saw the need to consider retrospective versus prospective attribution. Ryan, et al., found several advantages and disadvantages to each approach. The authors found that retrospective attribution allows for assignment based on how care was actually delivered but does not allow clinicians to know which patients will be assigned to them until after care has been provided. The authors note that prospective attribution removes this uncertainty but raised concerns about the possibility of gaming or providing differential levels of care based on attribution status. Additionally, there are concerns that patients can seek care from units other than the ones they are attributed to, and this could lead to inaccurate representations of the care provided.

The environmental scan found that the majority of current models use retrospective attribution but noted increasing uptake of prospective attribution. For example, the Medicare Shared Savings Program was initially designed to use retrospective attribution, but changes have been made to implement different tracks, some of which used prospective attribution.[11] Next, the Committee noted the need to consider the measurement period during which outcomes are tracked. The Committee stressed the importance of considering the relationship between the measurement period and the period in which patients are attributed to an accountable unit and the need to align the performance periods for payment and quality measures.

The Committee also recognized the importance of the measurement period and the defined time period for which an accountable unit is held responsible. The Committee noted some potential trade-offs for the measurement period. As Ryan, et al., noted in the commissioned paper, a longer time period increases the ability to identify a relationship between a patient and an accountable unit.[12] Longer time periods may also increase the likelihood that the patients attributed to a unit accurately reflect their patient pool.[13] However, the authors cautioned that using a longer time period may introduce the risk of including patients that only received low levels of care. The Committee and the authors also cautioned that patients may frequently change clinicians or providers, making longer time periods potentially inaccurate. One study found that only 67 percent of patients were attributed to the same accountable unit in the following year.[14] Attribution models must balance these concerns and ensure that the time period holds the correct units accountable.

Overall, commenters supported the Attribution Model Selection Guide. One commenter cautioned that concerns around sample size should not be used to create an unrealistic standard. The commenter suggested that implementers avoid rating specific entities with an inadequate denominator rather than not using a measure. The commenter also noted the importance of both reliability and validity and suggested that the findings of reliability and validity testing be considered in the Attribution Model Selection Guide.

Implementation and Evaluation of Attribution Models

As illustrated by the Attribution Model Selection Guide, designing an attribution model involves careful consideration and balance of many factors. The elements examined in the Attribution Model Selection Guide are an attempt to provide greater standardization of attribution models while laying out a series of considerations that measure developers and program implementers must address when designing an attribution model. As noted above, the current evidence does not support recommending one approach over another for a given circumstance. Rather, the selection tool is intended to help those developing attribution models think through what approach may be best for their circumstance rather than relying on the most convenient approach.

The Attribution Model Selection Guide aims to standardize the elements of an attribution model allowing for better comparisons between models and stronger evidence about which approach may be best in a certain situation. Developing this evidence will allow for evaluation of attribution models in the future. With this in mind, the Committee made a series of recommendations to guide those seeking to implement attribution models. The recommendations aim to aid implementers in designing and selecting attribution models to ensure that the desire for improvement and accountability is balanced with accuracy and actionability.

Finally, the Committee emphasized the need to fully examine the potential consequences, both intended and unintended, of the attribution model. How outcomes are attributed can significantly affect both patients and accountable units. Patients need accurate information to make decisions about where to seek care. Accountable units need to have control over the outcomes attributed to them to ensure fairness in reporting and reimbursement.

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RECOMMENDATIONS FOR ATTRIBUTION MODELS

The Committee's recommendations build on the guiding principles and Attribution Model Selection Guide. They are intended to apply broadly to those developing, selecting, and implementing attribution models in the context of public- and private-sector accountability programs. In their deliberations on the recommendations, the Committee recognized the current state of the science, considered what is achievable now, and what is the ideal future state for attribution models. The Committee stressed the importance of aspirational and actionable recommendations in order to drive the field forward.

RECOMMENDATION 1

Use the Attribution Model Selection Guide to evaluate the factors to consider in the choice of an attribution model.

Given there is currently no single gold standard attribution model, the choice of an attribution model should be dictated by the context in which it will be used and supported by evidence. The Committee recommended using the Attribution Model Selection Guide to evaluate the trade-offs in choosing an attribution model (Figure 3). Providing a clear rationale for choosing a particular attribution model can help foster trust among stakeholders. Measure developers and program implementers should be transparent about the potential trade-offs between the accountability mechanism, the gap for improvement, the sphere of influence of the accountable unit over the outcome, and the scientific properties of the measure considered for use.

In some cases, the sphere of influence of the accountable entity may be aspirational. For instance, one might choose an attribution model that attributes care to accountable entities with varying degrees of influence over the outcomes to incentivize those with less influence to partner with those who have more influence. Accountable entities have varying degrees of influence over a given outcome and need to partner with others in the community to meaningfully influence that outcome—as in the case of hospitals in the smoking cessation example noted above.

The selection and application of an attribution model should be accompanied by an explanation of the goals and purpose of measurement, the rationale used to identify the specific attribution methodology, and the intended and unintended consequences considered during the selection process. For example, physicians might avoid caring for high-cost patients because of concerns that having these patients attributed to them could negatively affect their reimbursement or reputation.

The Committee also noted the need to ensure that the attribution model fits the intended population. The Committee recognized the need to acknowledge a breadth of patient types and ensure that an attribution model works across populations.

Public commenters noted the need to identify factors outside of a provider's or clinician's control that can influence outcomes. Commenters noted challenges including the role of social risk factors, the role of patient motivation, the dependency of some groups like infants and children on caregivers to engage with the healthcare system, and the challenge in connecting with patients assigned to a clinician's panel but not actually seen.

FIGURE 3. ATTRIBUTION CAN OCCUR AT THE PROGRAM LEVEL AND THE MEASURE LEVEL:
This figure depicts when the Attribution Model Selection Guide should be applied.
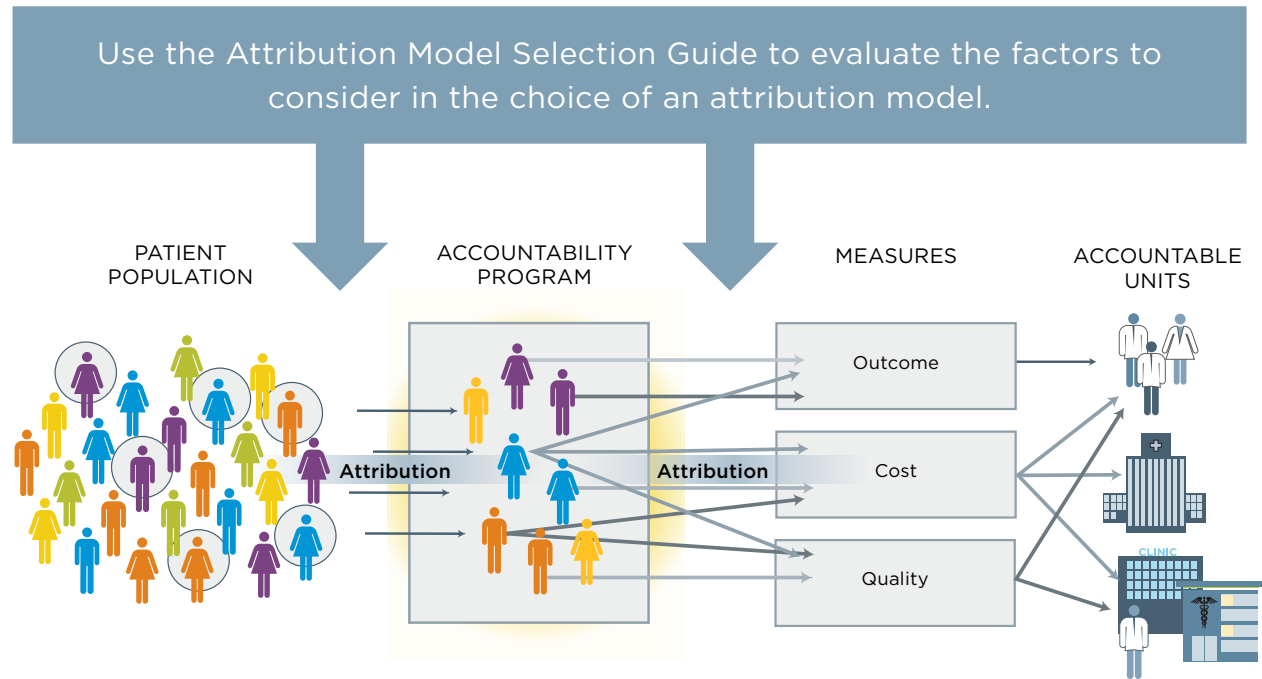
RECOMMENDATION **2**

Attribution models should be tested.

The literature demonstrates that attribution of patients to particular units is sensitive to the attribution rules used. Therefore, the measure developer or program implementer must subject attribution models to some degree of testing for goodness of fit, scientific rigor, and unintended consequences. Ideally, this would include sensitivity analyses comparing alternative attribution models. Testing could include comparing across different attribution models what fraction of patients is attributed and consistency of assignment. The degree of testing may vary based on the stakes of the accountability program. Attribution models would be improved by making the results of such testing public. Pilot testing may be acceptable under certain circumstances such as private reporting. This testing would generate data to determine

whether the attribution model is achieving what was intended. If so, the attribution model could be used for higher stakes applications. When used in mandatory accountability programs, attribution models should be subject to testing that demonstrates adequate sample sizes, appropriate outlier exclusion and/or risk adjustment to fairly compare the performance of attributed entities, and sufficiently accurate data sources to support the model in fairly attributing patients/cases to entities.

One concern from the Committee was that that quality measures developed for one setting (e.g., readmission rate for hospitals) frequently are translated to other settings (e.g., readmission rate for skilled nursing facilities). The Committee acknowledged that attribution models may sometimes be inherited as part of programs, but it asserted that this should not obviate the need for testing the models for goodness of fit and considering unintended consequences.

The Committee noted the need to ensure that attribution models work for different populations. The Committee recognized concerns about the need for special consideration for certain areas such as pediatrics, oncology, and behavioral health. The Committee recommended testing in multiple populations to ensure that the model performs similarly across populations.

Public commenters recommended that attribution models be regularly reviewed and updated. One commenter noted the need to monitor the impact of attribution models on clinicians and providers as well as on patients, particularly children and their families, and to determine if additional modifications are needed to ensure appropriate attribution. Commenters noted that accountable units should be advised with sufficient notice if attribution models are modified. Commenters also stated the need to simplify the number of attribution approaches and recommended moving to more uniform models, particularly across Medicaid Managed Care. Finally, commenters asked for additional guidance and parameters on what would be considered adequate testing and the optimal testing results that should be sought, noting that this level of detail is not required by the current NQF Consensus Development Process (CDP).

Attribution models should be subject to multistakeholder review.

Attribution model selection and implementation decisions should involve multistakeholder engagement. Given the current lack of evidence on the gold standard for attribution models, perspectives on which approach is best could vary based on the interests of the stakeholders involved. The Committee emphasized the importance of multistakeholder review and engagement in decisions around the strengths and weaknesses, trade-offs, and unintended consequences of different attribution models.

No one sector or stakeholder group should make decisions about attribution models for all others, and true stakeholder input requires adequate time for review and comment. Attribution model selection in the public and private sectors should use multistakeholder review to consider which model best suits the purposes at hand.

One way to achieve this is through local or regional collaborative groups with multiple stakeholders, or the NQF multistakeholder committees. The Committee also noted that multistakeholder groups should be involved in the development of payment models and quality initiative programs.

As part of the NQF Consensus Development process, standing committees could evaluate the attribution model of a performance measure. The approach and level of attribution of a particular measure may or may not be aligned with the goals of the program for which it is proposed, and its use in the program may affect the reliability and validity of a performance measure. The CDP could consider the change in behavior that the attribution model is designed to incentivize, whether the change is aspirational or reflects current practice, and whether it is acceptable to program stakeholders. Incorporating consideration of a measure's attribution model into the CDP would ensure the scientific acceptability and facilitate stakeholder acceptance of a measure's attribution approach. Similarly, the Measure Applications Partnership (MAP) could ensure alignment between the attribution model of a measure and the program in which it will be used. MAP committees could examine the attribution model of a measure when making pre-rulemaking recommendations to ensure that the measures are attributed at the level at which they were tested and endorsed when used for accountability purposes.

Commenters highlighted the need for transparency about attribution models. Commenters noted the challenges involved when attribution models are not implemented

uniformly. However, commenters cautioned that multistakeholder review must be balanced with the need to improve.

Attribution models should attribute results to entities who can influence care and outcomes.

The Committee was concerned that some attribution models in current use assign care to entities that have little control or influence over patient outcomes. For instance, models that use plurality of visits can attribute costs and outcomes to clinicians or facilities that have seen a patient more frequently to address an acute issue resulting from care delivered by a different clinician or facility.

In a fair, meaningful attribution model, an accountable unit must be able to influence the outcomes for which it is being held accountable either directly or through collaboration with others. As teams increasingly deliver care and facilities become more integrated, attribution models should reflect what the accountable entities are able to influence rather than directly control. For example, a clinician or facility could affect a patient outcome either directly or through collaboration with partners whom they can reliably influence. For readmissions measures, for example, a hospital being held accountable for readmissions from a skilled nursing facility (SNF) may ensure that the facilities to which it is discharging patients are meeting the hospital's standards to reduce readmissions. Additionally, an acute care physician or nurse practitioner could follow up with patients while they are in the SNF to ensure appropriate care is being delivered.

The Committee recognized, however, that there is often a grey zone in which theory or limited evidence suggests that clinicians or facilities can potentially improve patient care in collaboration with others, but the ability of any given provider to achieve the desired outcome through collaboration is uncertain. For example, a hospital may have no choice over which SNF to choose: A health plan may dictate the choice, only one SNF may have available beds, or an SNF may refuse to work with a hospital. The Committee recognized the tension between the current state and attempting to drive change through an aspirational assignment of responsibility. Performance measures and payment models are tools to move the system forward and incentivize behaviors that will improve quality and lower costs. However, higher stakes applications that affect clinician or facility reputation or payment require the measured unit to have a higher degree of influence over the results.

Public comments asked for greater clarity around the term influence care and outcomes. One commenter suggested building on the NQF measure evaluation criteria that require a relationship between the outcome of interest and healthcare structures or processes, while another suggested focusing on proximal outcomes. One commenter noted current limitations in a hospital's ability to influence readmission rates as an example of an attribution challenge.

Attribution models used in mandatory public reporting or payment programs should meet minimum criteria.

The results of an attribution model can significantly affect the reputation and payment of a clinician or facility, particularly in high stakes accountability applications such as public reporting or pay-for-performance programs. Given concerns from clinicians that they do not know why certain patients were attributed to them, it is important to have a transparent system. Clinicians should be able to examine why a patient's care was attributed to them, and there should be open adjudication processes that allow for appeals and refinements to the attribution model.

In order to be applied to mandatory reporting or payment program attribution, models should:

- use transparent, clearly articulated methods that produce consistent and reproducible results;

- ensure that accountable units can meaningfully influence measured outcomes (see recommendation 4);

- use adequate sample sizes, outlier exclusion, and/or risk adjustment to fairly compare the performance of attributed units;

- undergo sufficient testing with scientific rigor at the level of accountability being measured (see recommendation 2);

- demonstrate that the data sources are sufficiently robust to support the model in fairly attributing patients/cases to entities; and

- be implemented with an open and transparent adjudication process that allows for timely and meaningful appeals by measured entities.

Applying these criteria to attribution models used in mandatory payment or public reporting programs allows other attribution models to enter the field for experimentation and to incentivize entities to find new and innovative ways to partner to improve care and quality. The requirement of "adequate enough data to support the model" allows for imperfect data sources, but still requires data accuracy.

CONCLUSION

As the healthcare system continues its push towards value-based purchasing, particularly alternative payment models, it is essential that attribution models that assign accountability for a patient's care accurately reflect the relationship between that patient and the accountable unit. A range of approaches to building an attribution model currently exist, and the evidence is not conclusive in recommending one approach over another. The Committee recognized that attribution can be a tool to help advance healthcare improvement and to assign responsibility for complex outcomes. Attribution is essential as the system moves towards population-based payment models that seek to assign units responsibility for population health management. Attribution can be a mechanism to advance care coordination and incentivize units to think beyond their usual ways of delivering care to create a more person-centered system.

However, the Committee noted the limitations to current attribution models. Current models may be too complex, and the details of their algorithms are not available to the entities being held accountable. Furthermore, current models can be inaccurate and assign outcomes to units outside the scope of their practice or that they are not able to meaningfully influence. At the extreme, some models may hold units responsible for patients they have never seen.

To improve attribution models, further research is needed on ways to quantify relationships and understand the sphere of influence of an accountable unit. Additional research could help to provide a better understanding of the current issues and potential best practices, including a better understanding of current issues from the perspectives of patients and clinicians. In particular, the Committee noted a need to better understand how more expensive or complex

cases are managed. Qualitative research involving both patients and clinicians could help illuminate some of the inaccuracies with current models and opportunities for improvement in them. A better understanding of why a patient was attributed to a clinician and how that attribution actually aligned with who had influence over that patient's care could help improve attribution models.

Better data sources and analytic techniques should be explored to support more accurate attribution in the future. Patient relationship codes in electronic health records (EHRs) and increased use of National Provider Identifiers (NPIs) have potential to improve data, which could promote more accurate assignment of accountability.

The Committee also recognized the importance of engaging the patients and clinicians reflected by an attribution model. Patient attestation allows patients to decide which clinician should be accountable for their care. It can confirm that a model accurately represents a patient's relationship with a clinician. Likewise allowing clinicians to better understand why a patient was attributed to him or her will encourage buy-in into attribution models.

The Attribution Model Selection Guide presented in this report aims to create greater standardization among attribution models and aid decisions in selecting and implementing them. While the Committee recognized that one model will not fit all purposes, greater standardization of the elements of an attribution model will allow for more objective evaluation of how a model performs and which approach might best fit the goals that the model is trying to achieve. The Committee recommended transparency on the decisions made in developing or selecting attribution models and the potential trade-offs considered by measure developers and program implementers. The Attribution

Model Selection Guide offers a way to make clear and consistent decisions in selecting and implementing attribution models. Empirical research, and experience with evaluating these models in multistakeholder forums, may help to illuminate opportunities for objective evaluation of attribution models in the future.

As attribution models become standardized, evaluation of models will become more feasible. As the Committee highlighted in its recommendations, attribution models should be subject to multistakeholder review given the influence that stakeholder perspective can have. The Committee stressed the need to develop an evidence base that will allow evaluation of attribution models. Additional work is needed to develop processes to allow these reviews, including work to modify the NQF measure evaluation criteria to ensure that attribution is appropriately considered. More work is needed to determine how to test the reliability and validity of attribution models and to ensure that they appropriately handle specific patient populations including pediatrics, oncology, behavioral health, and rural or underserved areas. Specifically, the Committee noted the need to explore the minimum number of patients necessary to achieve

reliability and to research the effects of level of analysis on the reliability of attribution.

The Committee recognized the need to ensure greater person and family engagement in attribution. Specifically, the Committee highlighted the need to better understand what patients think their clinicians and providers should be held accountable for. The Committee also recognized the need to ensure that attribution models do not generate misinformation as consumers become increasingly engaged in choosing where to seek care. Attribution models should support accurate public reporting. Again, the Committee called for greater transparency of attribution models to ensure accuracy. Better understanding the reasons for inaccuracies in current models, leveraging new data sources, and standardizing elements of attribution models to allow for evaluation and comparison will all help improve attribution. Attribution models that truly reflect a patients' relationships with their clinicians and healthcare providers are essential to ensuring value-based purchasing can drive the system to better quality at lower costs. Sound attribution models are essential to ensuring that value-based purchasing can drive the healthcare system to better quality at lower cost.

ENDNOTES

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APPENDIX A:
Committee Roster, Biographies, and NQF Project Staff

Multistakeholder Committee Roster

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Harvard Medical School
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Manatt Health Solutions
New York

Michael Barr, MD, MBA, MACP
Executive Vice President of Quality Measurement &
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National Committee for Quality Assurance
District of Columbia

Jenny Beam, MSc
Vice President of Operations
University of Louisville Physicians
Kentucky

Jill Berger, MAS
Former Vice President
Health & Welfare for Marriott International
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Family Physician
Population Health Lead, Village Family Practice of
Fort Bend
Texas

Charles Hawley, MA
Analytics Lead
Utah Department of Health
Utah

Ari Houser
Senior Methods Advisor
AARP Public Policy Institute
District of Columbia

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Assistant Professor of Emergency Medicine
University of Michigan
Michigan

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Interim Head of Care Delivery, Aetna Accountable
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Premier, Inc.
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Public Health, University of Minnesota
Minnesota

Jennifer Nowak, RN, MSN
Center for Clinical Value
Blue Cross Blue Shield Association
Illinois

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Heller School, Brandeis University
Massachusetts

Brandon Pope, PhD
Director of Analytics
Baylor Scott & White Quality Alliance
Texas

Laurel Radwin, PhD, RN
Research Health Scientist
Boston Veteran Administration Healthcare System
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Michael Samuhel, PhD
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Booz Allen Hamilton
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Robert Schmitt, FACHE, FHFMA, MBA, CPA
Chief Executive Officer
Gibson Area Hospital & Health Services
Illinois

Nathan Spell, MD
Associate Professor of Medicine, Medical Educator
and Service Track and Vice Chair for Quality and
Clinical Effectiveness
Emory University School of Medicine
Georgia

Srinivas Sridhara, PhD, MS
Chief, Cost and Quality Analysis
Maryland Health Care Commission
Maryland

Bharat Sutariya, MD, FACEP
Vice President & Chief Medical Officer Population
Health
Cerner Corporation
Missouri
Federal Liaison

Lawrence Daniel Muldoon, MA
Social Science Research Analyst
Center for Medicare and Medicaid Innovation
Maryland

Biographies

Ateev Mehrotra, MD, MPH (Co-Chair)
*Department of Health Care Policy, Harvard Medical
School*

Dr. Mehrotra's research focuses on interventions
to decrease costs and improve quality of care.
Much of his work has focused on innovations in
delivery such as how retail clinics and e-visits affect
quality, costs, and access to healthcare. He is also
interested in the role of consumerism and whether
price transparency and public reporting of quality
can impact patient decision making. Related work
has focused on quality measurement including how
natural language processing can be used to analyze
the data in electronic health records to measure
the quality of care. Dr. Mehrotra received his B.S.
from the Massachusetts Institute of Technology, his
medical degree from the University of California, San
Francisco, and completed his residency in internal
medicine and pediatrics at the Massachusetts General
Hospital and Children's Hospital of Boston. His clinical
work has been both as a primary care physician and
as an adult and pediatric hospitalist. He also has

received formal research training with a masters
of public health from the University of California,
Berkeley, and a master of science in epidemiology
from the Harvard School of Public Health. In 2008,
he received the Milton W. Hamolsky Award for
Outstanding Scientific Presentation by a Junior
Faculty Member by the Society of General Internal
Medicine. In 2013, he received the Alice S. Hersh New
Investigator Award from AcademyHealth for health
services researchers early in their careers who show
exceptional promise.

Carol Raphael, MPA (Co-Chair)
Senior Advisor, Manatt Health Solutions

Carol Raphael served as president and chief executive
officer of the Visiting Nurse Service of New York
(VNSNY), the largest nonprofit home health agency
in the United States from 1989 to 2011. Prior to
joining VNSNY, Ms. Raphael held executive positions
at Mt. Sinai Medical Center and in New York City
government. In 2012, Ms. Raphael was an Advanced
Leadership Fellow at Harvard University. In 2013, Ms.
Raphael was appointed by President Obama to the
Bipartisan Commission on Long Term Care. She is co-
chair of the National Quality Forum MAP Post-Acute/
Long Term Care Workgroup and a member of its
Committee on All-Cause Readmissions. She is co-chair
of the West Health Advisory Council on Emergency
Department to Home-based Healthcare. She is chair
of the Long Term Quality Alliance, a Senior Advisor
at Manatt Health Solutions, and a board member
of the New York eHealth Collaborative, a public-
private partnership to advance the adoption of health
information technology. She is the chair of the AARP
board and serves on the boards of the Primary Care
Development Corporation, the Medicare Rights
Center, Pace University, Henry Schein, Inc., and ATE as
well as numerous advisory boards. She is a member
of the New York City Age-Friendly Commission and
edited the book *Home Based Care for a New Century*.

Michael Barr, MD, MBA, MACP
*Executive Vice President of Quality Measurement &
Research, National Committee for Quality Assurance*

Michael S. Barr is a board-certified internist and
executive vice president for the Quality Measurement
& Research Group at NCQA. His portfolio at NCQA
includes performance measurement development and
testing, contract/grant management, research, and
collaboration across NCQA on strategic initiatives,
public policy, and program development. Prior
to joining NCQA in May 2014, Dr. Barr was senior
vice president, Division of Medical Practice for the

American College of Physicians (ACP) where he was responsible for promoting patient-centered care through the development of programs, services, and quality improvement initiatives for internists and other healthcare professionals.

Jenny Beam, MSc
Vice President of Operations, University of Louisville Physicians

Jenny Beam, vice president of operations for University of Louisville Physicians, has delivered national presentations on productivity, benchmarking, labor management, and quality and process improvement at engineering and healthcare conferences. Jenny has also served on the National Quality Forum eMeasure Format Review Committee for Health Information Technology Panel. Jenny was responsible for analyzing and establishing the first generation patient attribution model for all quality and stars programs for a large national health plan and evaluated and scored providers and medical groups on evidence-based quality metrics. She is currently pursuing her second masters of science in social work.

Jill Berger, MAS
Former Vice President of Health & Welfare for Marriott International

Jill is an executive consultant—health care for IBM Watson Health. She brings her expertise in health care management to developing innovative solutions for employers and health plans to transform healthcare. Jill was formally the Vice President of Health & Welfare for Marriott International, one of the nation's largest hospitality vendors. She was responsible for the strategy, design, and management of Marriott's benefit plans—honing in on the need for quality improvement and greater engagement with employees about their health. Jill is a strategic health benefits professional with a passion to provide optimal population health management. Jill designed a global well-being program and implemented on-site clinics, health coach programs, and other initiatives to greatly improve employee engagement. Jill served on the Maryland Health Quality and Cost Council and the board of directors for the Integrated Benefits Institute. Jill was also co-chair for the National Business Group on Health (NBGH) Institute on Health Care Costs and Solutions. Jill was on the board of directors for the Leapfrog Group, and was chair from 2007-2009.

Anne Deutsch, PhD, RN, CRRN
Senior Research Public Health Analyst, RTI International

Anne Deutsch is a Senior Research Public Health Analyst with RTI International, a research scientist at the Rehabilitation Institute of Chicago's Center for Rehabilitation Outcomes Research, and a research associate professor at Northwestern University's Feinberg School of Medicine. She is a certified rehabilitation registered nurse with a doctoral degree in epidemiology and community health. Her research has focused on post-acute care patient outcomes, quality measurement, the impact of Medicare policies, post-acute payment reform, analysis of post-acute care payment episodes, the development of standardized assessment data elements, and the development of process and outcome quality measures.

Elizabeth Drye, MD, SM
Director of Quality Measurement Programs, Yale-New Haven Hospital, Center for Outcomes Research and Evaluation (CORE)

Dr. Drye is director of Quality Measurement Programs at Yale's Center for Outcomes Research and Evaluation (CORE) and a leader in quality measurement. She is currently focused on developing ambulatory care outcome measures. Before becoming a physician, she worked in national health policy positions in Washington, DC, including chief of staff at the White House Domestic Policy Council and legislative assistant to U.S. Senator Joe Lieberman. Dr. Drye received her MD from Harvard Medical School and SM in health policy and management from the Harvard School of Public Health. She completed her residency in pediatrics at Yale-New Haven Hospital.

Troy Fiesinger, MD
Family Physician, Population Health Lead, Village Family Practice of Fort Bend

Dr. Fiesinger completed his family medicine residency at the East Carolina University Brody School of Medicine in 1999 and practiced family medicine including obstetrics with the Scott and White Clinic in Waco, Texas, for seven years. While there, he served as the regional clinic director for quality and safety. For the past nine years, Dr. Fiesinger has served as faculty at community-based family medicine residency programs. During this time, he was the medical director of a federally qualified health center for two years. He also served on the board of directors of his health system's employed physician group. Dr. Fiesinger recently returned to private practice where

he provides comprehensive care to patients of all ages as part of a 30 physician primary care group. He is also the lead physician for population health and care management of their commercial managed care, Medicare Advantage, and Accountable Care Organization patients.

Charles Hawley, MA
Analytics Lead, Utah Department of Health

Charles Hawley has been a research consultant and health data analyst with the Utah Department of Health for the last four years. He currently serves as analytics team lead and cycle III grant manager with the Office of Healthcare Statistics. The office collects and analyzes Utah's health plan performance data, hospital discharge data, and All Payer Claims Database (APCD). Charles earned a master's degree in sociology from Kansas State University and an undergraduate degree in sociology and history from Weber State University. His graduate studies focused on quantitative research methods, social movements, and food systems.

Ari Houser
Senior Methods Advisor, AARP Public Policy Institute

Mr. Houser is a senior methods advisor in the AARP Public Policy Institute, where his work includes demographics, disability, quality and patterns of use of long-term services and supports, family caregiving, and methodological advising on many topics. Prior to joining the AARP Public Policy Institute, Mr. Houser worked at the RAND Corporation on a variety of topics including occupational health and safety management. He has a bachelor's degree from Swarthmore College and is a PhD candidate (ABD) in measurement, statistics, and evaluation at the University of Maryland.

Keith Kocher, MD, MPH, MPhil
Assistant Professor of Emergency Medicine, University of Michigan

Dr. Kocher is an emergency physician and health services researcher studying the delivery and performance of acute care, with particular interests in measurement development and its impact on payment and delivery system reform. He directs the Michigan Emergency Department Improvement Collaborative, a statewide project dedicated to measuring, evaluating, and enhancing the quality and outcomes of emergency department patients. He also has a career development award from AHRQ evaluating variation in hospitalization practice patterns from the emergency department, and

actively shapes performance improvement efforts within his professional society, serving on research and policy-oriented committees at the national level.

Robert M. Kropp, MD, MBA, CPHI
Interim Head of Care Delivery, Aetna Accountable Care Solutions

Dr. Kropp holds board certification in pediatrics, neurology, and clinical neurophysiology. He holds an MBA from the University of South Florida and a Certificate in Public Health Informatics from Johns Hopkins School of Public Health. During his tenure at Aetna he has held the titles of SE senior medical director and SE regional medical director. He is responsible for designing and delivering the collaborative clinical programs that Aetna and accountable care organizations use to improve quality, efficiency, and the patient experience. He has held a variety of titles and functions in the managed care industry, including chief medical officer for CIGNA Healthcare of Florida.

Danielle Lloyd, MPH
Vice President of Policy & Advocacy, Deputy Director, Premier, Inc.

Danielle Lloyd is the VP for policy development and analysis and deputy director of public affairs at Premier. Danielle leads Premier's policy analysis and development, which includes developing comments on federal legislative and regulatory proposals and research around the alignment of financial incentives to improve healthcare quality and reduce costs. She plays a leading role in Premier's ACO and Bundled Payment Collaboratives as well as Premier's nonprofit research arm, the Premier Research Institute. Danielle previously worked for the American Hospital Association, the California Hospital Association, the U.S. House of Representatives Committee on Ways and Means, and the Health Care Financing Administration.

Edison Machado, MD, MBA
Chief Quality Officer and Vice President of Strategic Planning

Dr. Machado is responsible for corporate strategic planning, business development and proposal services, and overseeing the corporate quality management system. In addition, he serves as the clinical lead for the CMS Innovation Center Episode Grouper for Medicare project. Finally, Dr. Machado acts as the medical director for IPRO's health informatics team. Dr. Machado worked as senior director in the Strategic Partnerships Department at

National Quality Forum where he was responsible for managing projects related to uses of healthcare performance measurement information for payment incentives, public reporting, accreditation and certification, workforce education, and systems improvement. Dr. Machado has also worked as medical director and programs leader for the Health Care Incentives Improvement Institute, Inc. (HCI3) where he oversaw the Bridges to Excellence (BTE) Care Recognition Programs, and while assisting various stakeholders and partners (including the American College of Cardiology, American Board of Internal Medicine, the NYS Health Foundation, and NYC Department of Health & Mental Hygiene) in managing and supporting healthcare quality performance measurement program implementations.

Ira Moscovice, PhD
Professor and Division Head, Division of Health Policy and Management, School of Public Health, University of Minnesota

Dr. Moscovice currently serves as the Mayo Professor and head of the Division of Health Policy and Management at the School of Public Health at the University of Minnesota. Dr. Moscovice is also the director of the Rural Health Research Center, one of eight federally funded rural health research centers in the United States. The center at the University of Minnesota focuses on rural quality, including measure development and analysis. Dr. Moscovice has served as a member of NQF's Measure Applications Partnership Steering Committee as well as co-chaired the NQF Rural Task Force.

Jennifer Nowak, RN, MSN
Center for Clinical Value, Blue Cross Blue Shield Association

Jennifer Nowak is a manager in the Center for Clinical Value at Blue Cross and Blue Shield Association, a national federation of 35 independent, locally operated Blue Cross and Blue Shield companies. She provides leadership developing and implementing programs to evaluate the value of care received by Blue Cross and Blue Shield members. Her primary focus has been on the Blue Distinction® program, a portfolio of designations awarded by Blue Cross and Blue Shield companies to providers for their delivery of value-based care. Jennifer received her nursing degrees from Rush University, and a bachelor's degree from University of Illinois, Champaign-Urbana.

Jennifer Perloff, PhD
Scientist, Deputy Director Institute on Healthcare Systems, Heller School, Brandeis University

Jennifer Perloff, PhD is a scientist and deputy director at the Institute for Healthcare Systems within the Schneider Institutes for Health Policy. Dr. Perloff has over 15 years of experience in evaluation and health services research. Currently, she is involved in a CMMI funded project to develop an episode grouper for Medicare (EGM). In addition to serving as project manager for this effort, Dr. Perloff is directly involved in analysis on attribution and provider profiling along with a range of other applied, claims-based studies. Dr. Perloff also teaches research methods to PhD students and sits on many dissertation committees.

Brandon Pope, PhD
Director of Analytics, Baylor Scott & White Quality Alliance

Brandon Pope is the director of analytics for the Baylor Scott & White Quality Alliance, an NCQA-recognized ACO with more than 4,000 physicians and 275,000 members. Brandon's primary responsibilities include delivering descriptive, predictive, and prescriptive analyses and insights in all areas of population health. Before joining Baylor Scott & White Health, Brandon worked as a research scientist for the Regenstrief Center for Healthcare Engineering and the School of Industrial Engineering at Purdue University. Brandon received his PhD and MEng degrees in industrial and systems engineering from Texas A&M University and his BS in mathematics from Abilene Christian University.

Laurel Radwin, PhD, RN
Research Health Scientist, Boston Veteran Administration Healthcare System

Laurel Radwin is a registered nurse with measurement experience and related methodologic expertise from using a variety of quantitative and qualitative methods. Laurel is recognized internationally for measures of nurses' contributions to patient outcomes, and is currently the lead investigator on three VA-funded initiatives that examine measurement of clinicians' and patients' perspectives on quality healthcare.

Jack Resneck, MD
Professor, Department of Dermatology School of Medicine, Professor, Philip R. Lee Institute for Health Policy Studies, University of California, San Francisco

Dr. Jack Resneck is professor and vice-chair of dermatology at UCSF, and holds a joint appointment

at UCSF's Institute for Health Policy Studies. His leadership roles at UCSF have included oversight of the medical center's Medicare physician quality reporting. Dr. Resneck is active in health services research. He currently serves as a trustee of the American Medical Association, and has advocated for physician engagement in data collection, as well as the development of meaningful, validated quality metrics with accurate attribution and risk-adjustment. Dr. Resneck received his B.A. in public policy from Brown University and completed his medical training at UCSF.

Michael Samuhel, PhD
Principal, Booz Allen Hamilton

Dr. Samuhel is a principal with Booz Allen Hamilton and a highly experienced executive with nearly 30 years of experience leading large units conducting research projects both domestically and internationally. His technical expertise includes surveys, statistics, epidemiology, and health IT. He currently leads large contracts with CMS to independently evaluate the effectiveness of the CMS Quality Improvement Organizations and develop innovative methods to properly attribute the return on investment from funds spent on these programs. Dr. Samuhel also leads the social sciences program for Booz Allen Hamilton, and he is responsible for the management and direction of multiple, large, or complex projects conducted by a staff of 75 professionals. He is active in several professional societies and serves on the board of directors of the North Carolina Health Information and Communications Alliance (NCHICA). He holds a PhD in statistics from American University.

Robert Schmitt, FACHE, FHFMA, MBA, CPA
CEO, Gibson Area Hospital & Health Services

With over 25 years in healthcare leadership, Robert Schmitt is the CEO of Gibson Area Hospital and Health Services. Rob is a Fellow of both the American College of Healthcare Executives and the Healthcare Financial Management Association. Rob received his master in business administration from Webster University on their Fayetteville, Arkansas, campus in 2001. Rob received his BS in accounting from Eastern Illinois University in 1988. Rob is also a certified public accountant. Rob has worked in small rural PPS hospitals, large PPS hospitals, and Critical Access Hospitals. In addition, Rob has extensive experience in physician clinics, operations and management of physician groups, and physician recruitment.

Nathan Spell, MD
Associate Professor of Medicine, Medical Educator and Service Track and Vice Chair for Quality and Clinical Effectiveness, Emory University School of Medicine

Nathan Spell, MD, FACP is a graduate of Harvard Medical School and trained in internal medicine at the Brigham and Women's Hospital. Dr. Spell began as an internist in the U.S. Air Force Medical Corps and transitioned to Emory University in 1998 as an associate professor of medicine. In 2006, he became chief quality officer of Emory University Hospital, leading a variety of quality improvement activities, development and delivery of training programs, and intentional efforts to enhance the culture of safety and service. In 2014, he became the vice chair for quality and clinical effectiveness in the Department of Medicine.

Srinivas Sridhara, PhD, MS
Managing Director, Clinician Analytics, Research & Development, The Advisory Board Company

Srinivas Sridhara has 15 years of experience in measure development, health services research, and health policy analysis. He is the managing director for clinician analytics at The Advisory Board Company (ABC), where he leads development of provider performance measures and tools to profile and incentivize high-value care. Prior to ABC, Dr. Sridhara worked at the Maryland Health Care Commission, where he managed Maryland's All Payer Claims Database and reported on healthcare costs, quality, utilization, and access; led price transparency initiatives, program evaluations, and workforce studies; and managed the IRB and data release program. Dr. Sridhara previously worked at Johns Hopkins Bloomberg School of Public Health (JHSPH) and Baltimore Mental Health Systems and completed his graduate work at JHSPH.

Bharat Sutariya, MD, FACEP
Vice President & Chief Medical Officer Population Health, Cerner Corporation

Bharat Sutariya is responsible for leading population health innovation strategy and solution design for Cerner. In this capacity, he collaborates with leaders across the company and industry to enhance Cerner's industry leading Population Health Platform and solutions. Dr. Sutariya is a thought leader across the healthcare industry on population health management and shared accountability between consumers, providers, and payers. He leads internal Cerner and client collaboration teams to develop solutions by integrating near real-time analytics, risk

and impact predictions. Prior to joining Cerner in 2004, Dr. Sutariya was leading healthcare information technology and clinical transformation across this integrated delivery network at Detroit Medical Center.

Lawrence Daniel Muldoon, MA (Federal Liaison)
Social Science Research Analyst, Center for Medicare and Medicaid Innovation

L. Daniel Muldoon has worked at the Center for Medicare and Medicaid Innovation (CMMI) since January 2014, primarily leading financial and analytic work for the Bundled Payments for Care Improvement Initiative and Oncology Care Model. Prior to joining CMMI, Mr. Muldoon was a staff economist at the Maryland Department of Budget and Management.

NQF Project Staff

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Erin O'Rourke
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Ashlie Wilbon, MS, MPH, FNP-C
Senior Director

Kim Ibarra, MS
Senior Project Manager

Donna Logan, MPH
Project Manager

Taroon Amin, PhD, MPH
Consultant

APPENDIX B:
Project Approach and Methods

General Approach and Timeline

NQF and the multistakeholder Committee used the approach and processes shown in Figure B1 and described below to complete this project.

FIGURE B1. FOUR STEP PROCESS FOR THE ATTRIBUTION PROJECT

Step 1 Convene multistakeholder Committee & commission researchers

Step 2 Conduct an environmental scan of attribution models and approaches

Step 3 Develop guiding principles, attribution model selection guide, and recommendations

Step 4 Obtain public comment and finalize principles, selection guide, and recommendations

Convene Multistakeholder Committee and Author Selection

NQF convened a 26-member Committee with diverse representation and knowledge from a variety of stakeholders, including consumers, purchasers, providers, clinicians, plans, suppliers, and healthcare quality experts. The Committee also included a federal liaison member from the Center for Medicare and Medicaid Innovation to inform the Committee of federal attribution models. NQF convened the multistakeholder Committee via a series of web meetings, in-person meetings, and conference calls throughout the project. Please see **Appendix A** for the full Committee roster.

Conduct an Environmental Scan of Attribution Models and Approaches

NQF commissioned a team of researchers to identify and evaluate current attribution models in healthcare. The commissioned paper (**Appendix F**) served as a foundation to inform the Attribution Committee's deliberations on recommendations for developing, selecting, and implementing attribution models in healthcare.

The researchers conducted an environmental scan to identify attribution models currently in use and those proposed but not implemented. These include retrospective and prospective attribution, whole and partial attribution, attribution for acute and chronic episodes, and primary care based and specialty-agnostic models. The commissioned paper includes technical issues related to attribution, implications for using alternative approaches in the context of various programs and payment modalities (e.g., fee-for-services and capitation), and an assessment of the fit between current attribution models and programmatic needs.

Develop Guiding Principles, an Attribution Model Selection Guide, and Recommendations for Attribution Models

Building on the commissioned paper, the Attribution Committee identified challenges to attribution and developed principles to address the challenges (see **first draft report**). Next, the Committee developed an Attribution Model Selection Guide to standardize elements of attribution models and help ensure decisions in developing and selecting attribution models can be made transparent. Finally, the Committee drafted recommendations for developing, selecting, and implementing attribution models.

Obtain Public Comment and Finalize the Principles, Selection Guide, and Recommendations

Throughout the project, NQF members and the public submitted comments on the draft reports and Committee's deliberations during web and in-person meetings. The Committee considered these comments in refining and finalizing the principles, Attribution Model Selection Guide, and recommendations.

APPENDIX C:
Overview of Comments Received

The National Quality Forum (NQF) received comments from the public and its members during two formal public comment periods: one after the draft principles and commissioned paper were published and the other after the draft report containing the Committee's principles, Attribution Model Selection Guide, and recommendations was published. The Committee revised the reports based on the comments received.

Comments on the Draft Principles

General Comments

Overall, there was support for the concepts and ideas presented within the principles. Some were unclear about what this project would be specifically addressing and requested clarification around the actual scope of the project. In particular, commenters asked for clarity on whether the Committee was focused on attribution for payment programs or attribution for specific measures. A number of comments expressed concern for the locus of control for physicians, especially if the principles were to be used for attribution for payment models. Inappropriate attribution models could result in the assignment of costs to physicians outside their locus of control. Commenters asked the Committee to expand its discussion about aligning attribution methodology with the goal of attribution. Commenters noted that attribution is most likely going to be defined differently depending on whether you are trying to figure out which physician was accountable for quality, which facility or physician contributed to particular elements of costs/spending and which ones contributed to savings, or to which ACO a patient should be attributed. Commenters raised potential data concerns, such as the lack of proper data and the possible substitution of patient attestation as

the best source of data. Commenters also stressed the importance of timeliness and the need to drive quality improvement

Language Changes and Specificity

Many comments suggested adding or removing words to clarify the points made, conveying the messages more clearly, and making the principles more specific. Some were concerned that the principles were too broad and should be more direct. The language in the principles was designed to be broad enough to encapsulate multiple scenarios, but simple enough to be understood. Commenters commended the simplicity, but believed further clarification was needed.

General Comments on the Commissioned Paper

Comments on the commissioned paper mostly centered on the language used and the inconsistency of terms. There was also concern that the content was too high-level. The inconsistency of the term "provider" in the commissioned paper was raised by commenters. Medicare law defines hospitals and other facilities as "providers" and defines physicians as "suppliers," which could lead to misunderstandings. The term "primary care provider" was not given a definition within the paper and commenters felt a definition was needed. The lack of granularity when discussing the strengths and weaknesses of the approaches to attribution was noted by a commenter. It was suggested that additional resources be added and broad statements be supported with specific evidence when discussing the models. Comments supported adding structure or proposed methods to address issues in attribution models noted

throughout the paper. Comments suggested aligning the language used throughout NQF's Attribution project with Health Care Payment Learning & Action Network's (LAN) white paper on attribution entitled *Accelerating and Aligning Population-Based Payment Models: Patient Attribution White Paper* to ensure consistency of approaches.

General Comments on the Draft Report

Overall, comments were positive comments and supportive of the Committee's approach, principles, and recommendations. Commenters specifically noted their appreciation that the Committee recognized that there is currently no evidence to support a gold standard for attribution, that in order to be fairly held accountable, providers and clinicians need to have the ability to influence care and outcomes, and that attribution models can be aspirational to change behavior, but they should be identified as such when being used. Commenters also praised the Committee's recognition that accurate and valid data are paramount, and transparency in attribution model decisions is critical.

Comments represented four themes: (1) highlight the patient perspective; (2) strengthen evidence, data, and testing; (3) outline the implementation strategy; and (4) provide additional guidance.

Highlight the Patient Perspective

Commenters highlighted the need to increase the focus on patients in the final report. Specifically, commenters asked the Committee to consider what attribution means to patients and public awareness of attribution and quality reporting data. They noted the potential for attribution models to have negative unintended consequences on patients if multiple clinicians think the other is responsible so no one takes full responsibility for a patient's care, or if vulnerable and complex patients are avoided. Commenters asked the Committee for guidance on how

to anticipate and address potential negative unintended consequences for patients, including guidance on risk adjustment and outlier exclusion in attribution models.

Strengthen Evidence, Data, and Testing

Commenters asked the Committee to expand on what "influence" means in the report. They emphasized the need for evidence linking outcomes to clinician action. One commenter suggested focusing on measuring proximal outcomes rather than weighting. Another commenter suggested requiring evidence of a relationship between the outcome of interest and structures and processes. Others asked the Committee to strengthen its recommendation on testing attribution models by providing guidance on the types and parameters of testing, including what degree of reliability testing should be required. Another set of comments emphasized that attribution cannot be performed without accurate data, but identified the need for common data standards and concerns about the accuracy of claims data for performing attribution.

Outline the Implementation Strategy

Commenters asked about the role of NQF and the role of measure developers and program implementers in operationalizing the Committee's recommendations. Commenters asked how NQF's standing committees would consider attribution challenges in measure evaluation, and how the recommendations and future evaluation of attribution models align with the current measure evaluation criteria used in the Consensus Development Process. While one person welcomed the opportunity for multistakeholder review of attribution models, that commenter also expressed concerns that reviewing attribution models moves the standing committees too far into the measure developer role. Other commenters asked about the feasibility of incorporating recommendations into the measure development process, and who would

be responsible for testing multiple attribution approaches before one is selected for program use. Commenters also asked how the appeals and adjudication process would be operationalized. They cautioned that it has the potential to undermine patient-centeredness and that it may be used by those with more resources.

Additional Guidance

Finally, commenters asked for additional guidance from the Committee in special circumstances, such as how to address attribution challenges in pediatric populations, behavioral health, Medicaid, and rural or under-resourced areas, and how attribution models can handle factors outside of a provider's locus of control such as social risk factors, patient motivation, and patients attributed but never seen by a clinician. Commenters expressed a desire for more uniform application of attribution models and suggested future work on recommending certain attribution models for certain use cases.

APPENDIX D:
Glossary

- **Accountable unit:** The entity whose performance is being measured, which could be a hospital, health plan, clinician, etc. Performance measurement can be applied to any setting and level of analysis.

- **Attribution**: The method used to determine which accountable unit is responsible for a patient's care and costs.[1]

- **Attribution model:** An attribution model is a set of rules to define the accountable unit for a patient's healthcare outcomes.

- **Assignment**: Used synonymously with "attribution"[2]

- **Aggregation**: The combination of units at a lower level (e.g., individual provider) to a higher level (e.g., provider organization). Attribution is a necessary condition for aggregation. [2]

- **Allocation**: The division of a performance indicator across different healthcare providers. For instance, 60 percent of healthcare spending may be allocated to provider A, and 40 percent may be allocated to provider B.[2]

- **Healthcare resource use**: Measures of healthcare utilization. Distinguished from measures of spending through the use of standardized prices.[2]

- **Healthcare spending**: Measures total healthcare spending, including total resource use and unit price(s), by payer or consumer, for a healthcare service or group of healthcare services associated with a specified patient population, time period, and unit(s) of clinical accountability.[2]

- **Outcome:** The result of providing healthcare. The term, outcome, will be used broadly to include the following types of outcomes relevant to performance measurement: quality outcomes of healthcare (e.g., mortality), intermediate clinical outcomes (e.g., BP < 140/90), patient-reported outcomes (e.g., depression), and economic outcomes of cost and resource use.

- **Population-based payment model:** A payment model in which a provider organization is given a population-based global budget or payment and accepts accountability for managing the total cost of care, quality, and outcomes for a defined patient population across the full continuum of care. [1]

- **Quality of care**: This report considers quality broadly, based on a modified version of the Institute of Medicine's aims for healthcare: safety, timeliness, effectiveness, equity, and patient-centeredness.[2]

- **Total cost of care (TCOC)**: A broad indicator of spending for a given population (i.e., payments from payer to provider organizations). In the context of performance-based payment (PBP) models, in which provider accountability spans the full continuum of care, TCOC includes all spending associated with caring for a defined population, including provider and facility fees, inpatient and ambulatory care, pharmacy, behavioral health, laboratory, imaging, and other ancillary services.[1]

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1   Health Care Payment Learning & Action Network. *Accelerating and Aligning Population-Based Payment: Patient Attribution*. 2016. Available at http://hcp-lan.org/workproducts/pa-whitepaper-final.pdf Last Accessed October 2016.

2   Ryan A, Linden A, Werner R, et al. *Attribution Methods and Implications for Measuring Performance in Healthcare: Commissioned Paper.* 2016.

APPENDIX E:
Illustrative Examples of the Attribution Model Selection Guide

CASE STUDY

Medicare Spending Per Beneficiary, Hospital Value-Based Purchasing

What is the context and goal of the accountability program?

What are the desired outcomes/results of the program?

Starting on October 1, 2012, Medicare began basing a portion of hospital reimbursement on performance through the Hospital Value-Based Purchasing Program (VBP). The VBP program aims to improve quality and lower costs by aligning financial incentives.

Is the attribution model aspirational?

The VBP program and MSPB measure aims to incentivize hospitals financially to improve care coordination, deliver efficient, effective care, and reduce delivery system fragmentation. Hospitals could do this by reducing readmissions through improved care coordination, ensuring they are working with high-value post-acute care partners, and by discharging patients to lower cost post-acute services when appropriate (e.g., using home health services rather than a skilled nursing facility when appropriate).

Is the attribution model evidence-based?

The MSPB measure advances VBP's goals to improve care coordination and efficiency by measuring the period between 3 days prior to an acute inpatient hospital admission through the period 30 days after discharge.

What is accountability mechanism of the program?

CMS withholds 2 percent of its regular hospital reimbursements from all hospitals paid under its inpatient prospective payment system (IPPS) to fund a pool of VBP incentive payments. Hospitals are scored based on their performance on each measure within the program relative to other hospitals as well as on how their performance on each measure has improved over time. The higher of these scores on each measure is used in determining incentive payments. CMS bases performance on a set of cost and quality measures grouped into specific domains. For FY 2018 these domains are Patient and Caregiver-Centered Experience of Care/Care Coordination (25 percent), Safety (25 percent), Clinical Care (25 percent), Efficiency and Cost Reduction (25 percent).

An MSPB episode includes all Medicare Part A and Part B claims paid during the period from 3 days prior to a hospital admission (i.e., index admission) through 30 days after discharge from the hospital. A hospital's MSPB measure is calculated as the hospital's average MSPB amount divided by the median MSPB amount across all hospitals, where a hospital's MSPB amount is the hospital's average price-standardized, risk-adjusted spending for an MSPB episode. Medicare payment amounts are price-standardized to remove the effect of geographic payment differences and add-on payments for indirect medical education (IME) and disproportionate share hospitals (DSH). In addition, the MSPB measure is risk-adjusted to account for beneficiary age and severity of illness.

Which entities will participate and act under the accountability program?

This program applies to hospitals paid under the IPPS system.

What are the potential consequences?

Potential positive consequences could include improved quality and care coordination and lower

costs; however, hospitals that have worse scores (higher costs) will be penalized financially, and that could create disincentives to admit more costly patients leading to barriers to access. Negative consequences could include taking resources away from underserved populations or a focus on the metrics in the program at cost to other outcomes. Additionally, there are concerns that the majority of variation on this measure is driven by post-acute spending that may be outside of the direct control of the hospital.

How do the measures relate to the context in which they are being used?

What are the patient inclusion/exclusion criteria?

Beneficiary populations eligible for the MSPB calculation include Medicare beneficiaries enrolled in Medicare Parts A and B who were discharged from short-term acute care hospitals during the period of performance.

Does the model attribute enough individuals to draw fair conclusions?

All IPPS hospitals are required to participate in the VBP program. However, the model should be tested to ensure appropriate performance in the program.

Which units will be affected by the attribution model?

Which units are eligible for the attribution model?

Hospitals paid under the Inpatient Prospective Payment System are included in the attribution model.

To what degree can the accountable unit influence the outcomes?

As noted above, hospitals could influence the outcome by reviewing spending by their post-acute partners.

Do the units have sufficient sample size to meaningfully aggregate measure results?

Issues of sample size may affect the reliability

and validity of these measures. The attribution model should be carefully reviewed to ensure that hospitals who are working to improve their results will benefit from the VBP program. Improper attribution could result in hospitals being mistakenly penalized.

Are there multiple units to which the attribution model will be applied?

The VBP program applies only to hospitals paid under the IPPS and the MSPB measure attributes spending to the hospital.

How is the attribution performed?

What data are used? Do all parties have access to the data?

The measure is calculated using claims data submitted by hospitals to CMS; hence, the attribution of the patient to the hospital is straightforward. Spending outside of the hospital per episode is calculated by linking patient claims across care settings using the patient Medicare ID number (HIC number), which is unique and has a high level of accuracy. Beneficiary populations eligible for the MSPB calculation include Medicare beneficiaries enrolled in Medicare Parts A and B who were discharged from short-term acute care hospitals during the period of performance.

What are the qualifying events, and do these events accurately assign care to the right accountable unit?

The measure includes the following resource use categories:

- Inpatient services: Evaluation and management

- Inpatient services: Procedures and surgeries

- Inpatient services: Imaging and diagnostic

- Inpatient services: Lab services

- Inpatient services: Admissions/discharges

- Ambulatory services: Outpatient facility services

- Ambulatory services: Emergency department

- Ambulatory services: Evaluation and management

- Ambulatory services: Procedures and surgeries

- Ambulatory services: Imaging and diagnostic

- Ambulatory services: Lab services

- Durable medical equipment (DME)

What are the details of the algorithm used to assign responsibility?

Spending for the included events is attributed to the hospital. The MSPB episode spans the period 3 days prior to the index hospital admission through 30 days post-discharge. All events that occur during this time period are included in the MSPB episode. However, the majority of the variation

in this measure is driven by post-acute spending. This may cause concerns as all spending is attributed to the hospital. There are also concerns that patients present with varying degrees of complexity that may influence spending needed for care.

Have multiple attribution methodologies been considered for reliability?

The measure's reliability was assessed during its NQF endorsement. However, additional testing may be necessary to ensure that the measure performs as expected in the program.

What is the timing of attribution computation?

Spending 3 days prior to an acute inpatient hospital admission through the period 30 days after discharge is attributed to the hospital.

CASE STUDY

Hemoglobin A1c (HbA1c) Measure in the Merit-Based Incentive Payment System (MIPS)

What is the context and goal of the accountability program?

What are the desired outcomes and results of the program?

Incentivize Eligible Clinicians in the Merit-Based Incentive Payment System (MIPS) to better manage their diabetic patients' HbA1c.

Is the attribution model aspirational?

Individual clinicians or group practices could choose to report this measure. The MIPS program and this measure aim to better incentivize further uptake of evidence-based practices, with the understanding not all patients will prioritize achieving the desired control over other considerations or be able to achieve the desired control.

Is the attribution model evidenced-based?

Yes, lower HbA1C levels can be achieved through optimizing care and lead to better health for patients (fewer short- and long-term complications).

What is the accountability mechanism of the program?

MIPS consolidates Medicare's existing incentive and quality reporting programs for clinicians. MIPS makes positive and negative payment adjustments for Eligible Clinicians (ECs) of many types (including primary care physicians, nurses, and physician assistants; physician subspecialists; and hospital-based physicians) based on performance in four categories:

- Quality—replaces current Physician Quality Reporting System (PQRS) program

- Cost—replaces current value-based modifier (VBM) program

- Advancing Care Information—replaces Meaningful Use program

- Improvement activities (new component)

Which entities will participate and act?

To meet the quality component, individual ECs or ECs in groups choose six measures to report to

CMS. One of these measures must be an outcome measure or other high-priority measure. Clinicians also can choose to report a specialty measure set. One measure clinicians can report is NQF #0059: Diabetes: Hemoglobin A1c Poor Control. This measure assesses the percentage of patients 18-75 years of age with diabetes (type 1 or type 2) whose most recent HbA1c level during the measurement year was greater than 9.0 percent (poor control) or was missing a result, or if an HbA1c test was not done during the measurement year. Poor control puts the individual at risk for complications including renal failure, blindness, and neurologic damage.

What are the potential consequences?

Potential negative consequences are that clinicians may avoid caring for high-risk or complex patients.

How do the measures relate to the context in which they are being used?

What are the patient inclusion/exclusion criteria?

The numerator of the measure is patients whose most recent HbA1c level is greater than 9.0 percent or is missing a result, or for whom an HbA1c test was not done during the measurement year. The outcome is an out-of-range result of an HbA1c test, indicating poor control of diabetes. The denominator is patients 18-75 years of age by the end of the measurement year who had a diagnosis of diabetes (type 1 or type 2) during the measurement year or the year prior to the measurement year. The measure excludes patients who did not have a diagnosis of diabetes, in any setting, during the measurement year or the year prior to the measurement year and who had a diagnosis of gestational diabetes or steroid-induced diabetes in any setting, during the measurement year or the year prior to the measurement year. The measure is not risk-adjusted.

Does the model attribute enough individuals to draw fair conclusions?

Clinicians must meet a Medicare patient volume threshold to be eligible for MIPS. Clinicians who

bill less than $30,000 dollars in Medicare Part B allowed charges or who are attributed less than 100 Medicare beneficiaries are excluded from the program. However, this measure could potentially address a subset of the patients that a clinician sees, that is, those with diabetes. It is important to test the measure within the context of the MIPS program to ensure that the model attributes enough individuals to ensure fair assessments of performance.

Which units will be affected by the attribution model?

Which units are eligible for the attribution model?

As noted above, individual clinicians or group practices can report this measure. This measure addresses an intermediate clinical outcome. Clinicians can work with patients to determine treatment to lower HbA1c to a desirable level.

To what degree can the accountable unit influence the outcomes?

The ability of ECs to influence their diabetic patients' HbA1C will vary across providers. Primary care doctors and endocrinologists can affect this measure through active management, patient engagement, and efforts at care coordination. However, patient preference, adherence to medications, engagement, adverse side effects, or competing clinical concerns, and social support, among other factors, may limit providers' control. Other types of providers will have less influence, but presumably will not select the measure for reporting.

Do the units have sufficient sample size to meaningfully aggregate measure results?

This measure should be tested in the MIPS context to determine a minimum sample size for a reliable measure score.

Are there multiple units to which the attribution model will be applied?

A diabetic Medicare patient is likely cared for by multiple providers. Under MIPS, however, patients are assigned to only one provider based on

where they get their primary care (see below). In cases where patient management is shared, and the providers seeing the patient are not all in the same group for the purposes of MIPS reporting, the patient outcome will be assigned to a single provider even though multiple providers potentially influence the outcome.

How is the attribution performed?

What data are used? Do all parties have access to the data?

The data source can be claims, web interface, registry, or electronic health record.

What are the qualifying events, and do these events accurately assign care to the right accountable unit?

It is estimated that over 600,000 clinicians will be subject to the MIPS program. As noted above, clinicians can choose which measures to report.

What are the details of the algorithm used to assign responsibility?

This measure assesses patients 18-75 years of age by the end of the measurement year who had a diagnosis of diabetes (type 1 or type 2) during the measurement year or the year prior to the measurement year.

Have multiple attribution methodologies been considered for reliability?

Reliability of the measure was assessed during the measure's NQF endorsement review. Additional considerations of the reliability of the measure within the context of the MIPS program should be assessed.

What is the timing of attribution computation?

The measurement period is one year.

SNF Readmissions Measure in the Skilled Nursing Facility Value-Based Purchasing (SNF VBP) Program

What is the context and goal of the accountability program?

What are the desired outcomes/results of the program?

Section 215 of the Protecting Access to Medicare Act of 2014 (PAMA) authorizes establishing a SNF VBP Program beginning with FY 2019 under which value-based incentive payments are made to SNFs in a fiscal year based on performance. CMS states that the goal of this program is to transform Medicare from a passive payer of SNF claims to an active purchaser of quality healthcare for beneficiaries by linking payments to performance on identified quality measures. This program attempts to address potentially preventable hospital readmissions by establishing an incentive pool for high performers.

Is the attribution model aspirational?

The program aims to reduce hospital readmissions from skilled nursing facilities by promoting shared accountability. As noted below, there is evidence to support the idea that SNFs can improve their processes or structures to reduce hospital readmissions. However, there have been concerns that a patient's risk of readmission is influenced by the quality of the hospital care they received and other factors outside the control of the SNF.

Is the attribution model evidence-based?

There is evidence that hospital readmissions can be reduced by improved care coordination and improvements in patient safety and care by SNFs.

What is the accountability mechanism of the program?

Based on the SNF readmission measure, the Secretary of HHS must establish a performance standard for SNFs, along with levels of achievement and improvement. The Secretary will then develop a scoring methodology for each SNF in order to create a ranking system to rate SNFs annually. The Secretary must ensure

that SNFs with the highest rankings receive the highest incentive payments and SNFs with the lowest rankings receive the lowest (or zero) incentive payments. The lowest 40 percent of SNFs (by ranking) will be reimbursed less than they otherwise would be reimbursed without the SNF VBP.

Which entities will participate and act?

The program includes skilled nursing facilities.

What are the potential consequences?

Potential negative consequences are that the program may reduce patient access to care if SNFs do not accept higher risk patients from hospitals.

How do the measures relate to the context in which they are being used?

What are the patient inclusion/exclusion criteria?

The following are excluded from the denominator:

1. SNF stays where the patient had one or more intervening post-acute care (PAC) admissions (inpatient rehabilitation facility [IRF] or long-term care hospital [LTCH]) which occurred either between the prior proximal hospital discharge and SNF admission or after the SNF discharge, within the 30-day risk window. Also excluded are SNF admissions where the patient had multiple SNF admissions after the prior proximal hospitalization, within the 30-day risk window.

2. SNF stays with a gap of greater than 1 day between discharge from the prior proximal hospitalization and the SNF admission.

3. SNF stays where the patient did not have at least 12 months of FFS Medicare enrollment prior to the proximal hospital discharge (measured as enrollment during the month of proximal hospital discharge and the for 11 months prior to that discharge).

4. SNF stays in which the patient did not have FFS Medicare enrollment for the entire risk period

(measured as enrollment during the month of proximal hospital discharge and the month following the month of discharge).

5. SNF stays in which the principal diagnosis for the prior proximal hospitalization was for the medical treatment of cancer. Patients with cancer whose principal diagnosis from the prior proximal hospitalization was for other diagnoses or for surgical treatment of their cancer remain in the measure.

6. SNF stays where the patient was discharged from the SNF against medical advice.

7. SNF stays in which the principal primary diagnosis for the prior proximal hospitalization was for "rehabilitation care; fitting of prostheses and for the adjustment of devices."

Does the model attribute enough individuals to draw fair conclusions?

This measure assesses unplanned all-cause hospital readmissions of SNF patients occurring within 30 days of discharge from the patient's prior proximal acute hospitalization. The measure was found to be reliable and valid during its NQF endorsement, but additional testing may be needed to monitor the results of this measure in this program.

Which units will be affected by the attribution model?

Which units are eligible for the attribution model?

This program uses NQF #2510 All-Cause Risk-Standardized Readmission Measure. This measure estimates the risk-standardized rate of all-cause, unplanned, hospital readmissions for patients who have been admitted to a Skilled Nursing Facility (SNF) (Medicare fee-for-service [FFS] beneficiaries) within 30 days of discharge from their prior proximal hospitalization. The prior proximal hospitalization is defined as an admission to an IPPS, CAH, or a psychiatric hospital.

To what degree can the accountable unit influence the outcomes?

As noted above, there is evidence that SNFs can influence the outcome by improving care coordination, patient care, and safety. However, there have been concerns about the influence of factors outside the SNFs control on the outcome of the measure.

Do the units have sufficient sample size to meaningfully aggregate measure results?

The measure is NQF-endorsed, but additional testing may be necessary to ensure that it is reliable and valid in the context of the program.

Are there multiple units to which the attribution model will be applied?

No, the program only applies to SNFs.

How is the attribution performed?

What data are used? Do all parties have access to the data?

This measure uses claims data.

What are the qualifying events, and do these events accurately assign care to the right accountable unit?

This measure captures 30 hospital readmissions and attributes responsibility to the SNF. Evidence has shown that there are interventions that SNFs can undertake to reduce hospital readmissions, but concerns have been raised that some readmissions may be out of the SNF's control.

What are the details of the algorithm used to assign responsibility?

A risk-adjusted readmission rate for each facility is calculated as follows: Step 1: Calculate the standardized risk ratio of the predicted number of readmissions at the facility divided by the expected number of readmissions for the same patients if treated at the average facility. The magnitude of the risk-standardized ratio is the indicator of a facility's effects on readmission rates. Step 2: The standardized risk ratio is then multiplied by the mean rate of readmission in the population (i.e., all Medicare FFS patients included in the measure) to generate the facility-level standardized readmission rate.

Have multiple attribution methodologies been considered for reliability?

The reliability of the measure was assessed during its NQF endorsement. However, additional testing for reliability may be needed to ensure that the measure appropriately performs in this program.

What is the timing of attribution computation?

The measure is based on data for 12 months of SNF admissions.

APPENDIX F:
Attribution Methods and Implications for Measuring Performance in Healthcare

A commissioned paper originally published September 24, 2016.
Authors: Andrew Ryan, Ariel Linden, Kristin Maurer, Rachel Werner, Brahmajee Nallamothu.

Purpose of the Commissioned Paper

This paper was commissioned by the National Quality Forum to identify and evaluate current attribution models in health care. This paper served as a foundation to inform the deliberations of a multi-stakeholder committee that will provide input and recommendations related to the use of attribution models in health care.

Attribution models are pre-specified rules that determine the specific patients, types of health care services, and the duration of care for which providers and organizations are responsible. Attribution of patients to providers is necessary to link indicators of patient-level health care quality and spending to specific providers for the purpose of profiling and accountability.

We conducted an environmental scan to identify the attribution models that are currently in use, as well as those that have been proposed but not implemented. These include retrospective and prospective attribution, whole and partial attribution, attribution for acute and chronic episodes, and primary care based and specialty-agnostic models. We will then discuss the challenges related to attribution and consider the relative merits of alternative attribution models. In addition to assessing the technical issues related to attribution, we consider the implications for using alternative approaches in the context of various programs—such as Accountable Care Organization programs and value-based payment—and payment modalities (e.g. fee-for-services and capitation). We will conclude with an

assessment of the fit between current attribution models and programmatic needs, and how models may be revised to better meet these needs.

Definitions

- **Attribution**: pre-specified rules that determine the specific patients, types of health care services, and duration of care for which providers and organizations are responsible

- **Assignment**: used synonymously with "attribution"

- **Aggregation**: the combination of units at a lower level (e.g. individual provider) to a higher level (e.g. provider organization). Attribution is a necessary condition for aggregation.

- **Allocation**: The division of a performance indicator across different health care providers. For instance, 60% of health care spending may be allocated to Provider A and 40% is allocated to Provider B.

- **Quality of care:** In this paper, we will consider quality broadly, based on a modified version of Institute of Medicine's aims for health care: safety, timeliness, effectiveness, equity, and patient-centeredness.

- **Health care resource use**: Measures of health care utilization. Distinguished from measures of spending through the use of standardized prices.

- **Health care spending**: Measures total health care spending, including total resource use and unit price(s), by payer or consumer, for

a health care service or group of health care services associated with a specified patient population, time period, and unit(s) of clinical accountability.

- **Providers**: denotes clinicians and health care organizations without respect to degree or sector (e.g. registered nurses, licensed practical nurse, primary care physician, specialist physician, hospitals, post-acute care facilities, etc.). Although different attribution rules may prioritize different types of clinicians, the individual clinicians who are eligible to have attributed patients are typically those who have a National Provider Identifier (NPI).

- **Primary care providers:** We define primary care providers using the guidance from CMS (2011): 1) A physician who has a primary specialty designation of family medicine, internal medicine, geriatric medicine, or pediatric medicine for whom primary care services accounted for the majority of services; or 2) A nurse practitioner, clinical nurse specialist, or physician assistant for whom primary care services accounted for the majority of services.

Section 1. Introduction

The current health policy environment has made attribution—the methods used to assign patients to providers for the purpose of accountability—critical. Patients often receive care from numerous providers. Providers have historically lacked accountability for managing patients across the continuum of care. The resulting system-failures from poorly coordinated care are perceived to be responsible for many of the spending and quality problems in the United States.

New system reforms are trying to change this. Accountability programs require a set of rules to define which patients or episodes will "count" for which providers. Some of the most notable are the Accountable Care Organization (ACO) programs that have been initiated by the Centers for Medicare and Medicaid Services. These programs make groups of provider organizations that voluntarily choose to be part of the ACO responsible for the total spending and quality performance of traditional Medicare beneficiaries.

ACO payment models require a method to attribute patients to a particular ACO for the purpose of accountability. A common model attributes patients exclusively to the ACO that provides the plurality of primary care services from primary care physicians. Another possible model would attribute patients to the ACO that provides the plurality of any services by any provider. The first approach will only attribute patients to an ACO that includes primary care providers. With more primary care providers, more patients would be attributed. The second approach could attribute patients to ACOs without primary care providers. The profound implications of these two models highlight the importance of attribution methods.

Attribution models matter beyond the ACO programs. Other accountability programs, such as the Physician Value-Based Payment Modifier and the soon-to-be-implemented Merit Based Incentive Payment System (MIPS) require attribution for the purpose of profiling physicians and group practices. Attribution is also critical in determining the hospitals, providers, and clinicians that will be accountable for care in the new episode payment programs. Attribution is most relevant in circumstances in which accountability has not been clearly defined (e.g. ambulatory care in fee-for-service medicine).

Attribution can range from being relatively straightforward (e.g. for hospital inpatient episodes), to moderately challenging, (e.g. 30/60/90 post-discharge episodes), to highly challenging and controversial (e.g. chronic disease management). Crucially, the implications of alternative attribution methods have not been rigorously evaluated and the field has not coalesced around best practices for attribution. Instead, logical approaches have been developed based on previous methods. For instance, the

approaches to attribution in the Medicare ACO programs were similar to those in the Physician Group Practice Demonstration.

To identify best practices for attribution, we must catalogue current approaches, identify criteria to assess their merits, and evaluate extant approaches with respect to appropriate clinical and programmatic contexts.

Section 2. Contextual Factors and Terms of Attribution

Attribution can occur for different types of patients treated under different clinical circumstances by different types of providers. The resulting attribution can be for individual providers, provider organizations, or groups of larger providers. Attribution can cover a narrow or broad set of services. The duration under which an attributed provider is accountable for a given patient can also vary. Our conceptual model (Figure F1) contends that appropriate attribution should be determined based on the type of patient, the clinical circumstances, and the provider(s) delivering care. These combinations of factors will lead to a patient being attributed to a certain provider (or providers), for a specific duration.

Different types of patients may merit different attribution strategies. While a default rule could attribute patients to primary care physicians, patients with specific chronic diseases (e.g. end-stage renal disease) should perhaps be attributed to certain specialists (e.g. nephrologists). Alternatively, attribution rules could make older patients more likely to be attributed to geriatricians or other specialists. The level of attribution (e.g. individual provider, provider organization, ACO) may affect the reliability and validity of performance measurement, as well as the incentives for accountability. Attribution rules may also seek to accommodate treatment patterns for patients in rural and urban areas. For instance, if a patient in a rural area receives extensive care at

a tertiary care facility that is a substantial distance from the patient's residence, should an attribution algorithm preferentially attribute the patient to a local physician or practice?

The clinical circumstances surrounding the attribution of patients to providers may also be relevant. For instance, for attribution of acute events (e.g. 90-day episode following hip or knee replacement), the standard practice is to attribute patients to a hospital based on an "index hospitalization." The index hospitalization is defined by the first hospitalization that initiates an episode: another hospitalization occurring within 30 days of the index hospitalization typically does not initiate a new episode. Thus, temporal precedence matters. However, for chronic care, attribution models, temporality has not typically mattered. Instead, patients are typically attributed to the physician providing the highest frequency or intensity of care for that chronic condition.

The providers whose care contributes to attribution is also relevant. On one hand, only primary care providers could contribute to attribution decisions. Alternatively, any provider could contribute to an attribution decision. In between, non-primary care providers could contribute to attribution only when a patient was not cared for by a primary care provider. The latter example provides a framework for customized attribution rules. These rules could hold that, optimally, certain patients should be attributed to certain providers under certain circumstances. If these conditions are not met, then attribution could default to a generic algorithm (e.g. plurality of primary care services).

After attribution occurs, the terms of accountability care vary across a number of dimensions. These include the type of services for which a provider is accountable (e.g. only care related to diagnostically defined episode, all care occurring within episode) and the duration of the episode (e.g. 30 days, 90 days, one year, or multiple years).

One final issue relevant to attribution concerns the data elements that are required. Medical claims are the most commonly used data source for attribution. Electronic health record data are an alternative, but imperfect given the priority of including data from providers from different organizations in attribution and the lack of interoperability of many EHRs. Patient/provider/payer designation or attestation could also be used for attribution, but would likely be most relevant for prospective attribution approaches.

Section 3. Environmental Scan of Attribution Approaches

We performed an environmental scan to identify the attribution methods that have been proposed or are currently in use for accountability applications in health care. Initially, we pursued a search strategy using a variety of key words and MESH headings such as (attribut*[Title/Abstract] OR assign*[Title/Abstract]) AND(("Insurance, Health, Reimbursement"[Majr]) OR ("Accountable Care Organizations"[Majr]) OR ("Cost Control"[Majr]). However, this strategy was too sensitive and not sufficiently specific: it identified large numbers of irrelevant articles while failing to generate results that spanned all situations in which attribution is applicable. For instance, the strategy query detailed above produced 658 hits; yet it would have been unlikely to pick up articles describing the attribution of episode of care to providers. Queries resulting in more comprehensive searches, however, yielded over 2000 results. To address this issue, we employed a "snowball" search strategy in which we identified 15 highly relevant sources that described attribution and/or present different attribution models for a variety of purposes including accountable care organizations, physician profiling, and pay-for-performance programs (Figure F2). We used Google Scholar to identify publications that have cited these papers and then reviewed the hits for sources that outline one or more attribution models. We also searched the

bibliographies of the initial 15 sources to identify additional relevant publications (Figure F3). No exclusions were made in either component of the search process based on the date of publication, location of study, or type of resource. As a result, our search generated a variety of materials including original research articles, editorials, and reports. To supplement our main search strategy, we used PubMed and Embase to identify additional examples of attribution models. The exact search terms and the results are outlined in Figure F4. This search uncovered 8 additional attribution models.

Overall, our environmental scan identified 84 sources describing 171 unique attribution models that have been proposed or are currently being used in accountability programs (Table F4 and Table F5). Attribution models were categorized by the following characteristics: 1. Clinical circumstances; 2. Type of provider attributed; 3. Payer/programmatic circumstances; 4. Timing of attribution (retrospective vs. prospective); 5. Exclusivity of attribution (single vs. multiple provider); 6. Period of time of which providers are accountable for attributed patients; 7. Minimum requirement to make an attribution (such as a plurality or a majority); and 8. Measure used in attribution process (such as spending or visits) (Table F1). Due to the absence of information in the descriptions of some attribution models, several assumptions were made during the process of identifying model characteristics. For instance, it was assumed that approaches using claims data were retrospective unless explicitly stated otherwise. Another common assumption made in the absence of information regarding exclusivity of attribution was that approaches with either a plurality or a majority rule would attribute patients to a single provider. For models tied to previously or currently implemented accountability programs, we cross-referenced outside sources in cases in which the descriptions found during the literature review were highly ambiguous. Even after taking these steps, some models were difficult to

characterize because they involved multiple steps and/or varying approaches for different patients.

Table F1 shows the characteristics of attribution approaches that were identified in the environmental scan (n=171). Of these approaches, 82.5% have been proposed but not implemented in a formal program and 17.5% have been implemented. Attribution to "any physician" was the most common type or provider attributed (48.5%), followed by attribution to primary care providers (PCPs) (15.8%). Most approaches employed retrospective attribution (88.9%) rather than prospective attribution (6.4%). Attribution approaches tended to focus on all care (45.6%) or care for particular episodes (39.2%). Most of the attribution models were studied among Medicare (43.3%) or commercially insured patients (32.7%). Attribution approaches tended to require attribution to only one provider (77.8%) rather than to multiple providers (19.3%). Visits (42.7%) and spending (30.4%) were the most common measures used to attribute patients to providers. However, the use of other approaches was also common (24.6%) and included approaches such as attributing patients based on their provider enrollment status. There was considerable variation with respect to the minimum criteria required for attribution: a plurality was the most common criteria (29.8%). Specific thresholds were enforced in 28.1% of approaches. Several (19.3%) models used other approaches. For examples, for some attribution models that spanned all programmatic circumstances, criteria varied depending on whether beneficiaries were enrolled with a physician as part of their health plan. The period of time for which the provider was responsible for attributed patients varied considerably across the models and in many cases the time period was not specified in model descriptions (39.2%). When duration was specified, the most common approach was to attribute patients for one year (29.2%). Other approaches such as the attribution of patients for the duration of an episode were also common (24.6%).

Table F2 shows the same set of characteristics of attribution approaches that were identified in the environmental scan among the implemented models (n=30). Compared to the characteristics of both the implemented and proposed models shown in Table F1, a greater share of the implemented models: were for ACOs (43.3% of implemented versus 10.5% of all); used prospective attribution (23.3% of implemented versus 6.4% of all); applied to all health care services (66.7% of implemented versus 45.6% of all); and were payer agnostic (30.0% of implemented versus 17.0% of all). The characteristics of implemented and all attribution models were similar with respect to exclusivity of attribution, the measures used for attribution, the minimum requirement for attribution, and the period of time over which attributed providers were responsible for attributed patients.

Table F3 shows the bivariate relationship between the type of attributed provider (ACO; any physician/physician group; and PCPs) and the characteristics of attribution approaches (n=149). It shows that attribution models that were applied to ACOs were more likely to use prospective attribution (38.9%), were some somewhat more likely to make attribution on the basis of the plurality of care (44.4%), and more likely to require accountability for one year (44.4%).

Section 4: Discussion

Challenges Related to Attribution

Many of the challenges surrounding attribution are related to the high dispersion of health care in the United States. Medicare patients see a median of two PCPs and five specialists that are associated with four different provider organizations in one year (Pham et al. 2007). The attribution of a patient to a provider implies that the provider is responsible for the care and/or influences the health outcomes of that patient. Providers are not inherently equal in their roles in patient care even when they have similar levels of contact with

patients. Because of this, it is often uncertain how to determine which patients should be attributed and which should be excluded. The issue of care dispersion creates additional challenges when selecting an appropriate method to attribute patients to providers.

Attribution approaches should be simultaneously reliable and valid. When large numbers of patients are attributed to providers, performance measures are more reliable, increasing the ability to distinguish performance across providers. However, because care is highly dispersive, choosing attribution approaches based on their ability to result in a large n for each provider risks including patients that only receive a small portion of care from a provider. This in turn can compromise the validity of the attribution process. Attribution methods must strike a balance of attributing enough patients and attributing patients for which providers are responsible. Concerns that it was invalid to attribute episode spending for heart failure to hospitals—when the disease is not primarily managed in the inpatient setting—was one of reasons why a heart failure spending measure (NQF #2436: Hospital-level, Risk-standardized Payment associated with a 30-day Episode-of-care for Heart Failure (HF)) initially failed to receive NQF endorsement (NQF 2015).

Attribution approaches should also be fair and equitable to both patients and providers. Attribution approaches that are closely aligned with how providers feel they are responsible for patients are more likely to be perceived as fair. In a system of highly coordinated care, attribution can more easily be designed to reflect the ways in which care is already being provided and therefore may be more favorable to providers. However, when patients receive care from multiple physicians and provider organizations, an attribution approach can instead be used as a tool to incentivize desirable system outcomes such as greater care coordination. In this case, some unfairness in the approach is expected

simply because providers will not have full control over patient outcomes. What is initially unfair can be transformed into an approach that is fair once providers implement systematic changes in the delivery of care. Yet, when attribution is used in this way, there is a tremendous challenge in devising an approach that pushes providers to make changes without being perceived as entirely out of reach. The different aspects of attribution models attempt to mitigate the challenges of linking patients to providers while being fair, reliable, and valid.

Strengths and Weaknesses of Different Attribution Approaches

Attribution approaches may involve linking patients to individual physicians or groups such as ACOs or hospitals. One of the advantages of assigning patients to larger units is that more patients can be attributed and thus estimates of provider performance can be more reliable (Fisher et al. 2006). Yet, because care can be dispersed across different groups of providers, this approach does not completely eliminate the challenge of accurately representing providers' patient populations.

Approaches that assign patients to physicians may further specify the type of physician to which patients can be attributed. Although for some clinical circumstances the choice of physician can be based on the type of service provided, attribution is more complicated for accountability programs assessing the delivery of primary care. Primary care is not always delivered by physicians that are typically defined as PCPs such as internists, generalists, and family medicine practitioners. As a result, some approaches will attribute patients to specialists, but the merits of this strategy as well as whether patients should be attributed to individuals or groups largely depend on the purposes of an accountability program. While empirical evidence does not currently support the relative merits of attribution approaches, rigorous justification of the elements

of attribution models would likely enhance attribution choices.

Retrospective attribution has the advantage of making assignments based on how care is actually delivered, but has the disadvantage that providers do not know who counts as their patients until after they have already provided care. Prospective attribution approaches remove uncertainty on the part of the provider. On one hand, from the perspective of providers, this may be fairer, but it also introduces the possibility of gaming or providing differential levels of care to patients based on attribution status. In the models using prospective attribution, even if patients are informed of their physician assignments, they are not precluded from seeking care outside of their designation. As a result, prospective attribution may lead to inaccurate representations of the care that providers actually provide. Although the vast majority of attribution models uncovered in our environmental scan utilize retrospective attribution, the debate over the virtues of the two methods does not appear to be resolved. The Medicare Shared Saving Program was originally designed to involve retrospective attribution, but has since implemented different programs tracks, some of which incorporate prospective attribution (Baseman et al. 2016). The provision of lists of patients that will likely be attributed to providers at the beginning of the measurement period is one approach that attempts to mitigate the uncertainty involved in retrospective attribution.

Most attribution models identified through the environmental scan involve all clinical circumstances (including primary care) or episodes of care rather than the attribution of acute or chronic care. Using episodes of care in the attribution process is advantageous in that care within an episode may be more highly concentrated among an individual physician or provider group (Damberg et al. 2009). In addition, there may be more clarity about the roles of different providers within an episode, making attribution more straightforward. Despite these

benefits, episodes of care are limited in their applications and may not be appropriate for all circumstances such as primary care or chronic conditions in which episodes are hard to define. Attribution to primary care providers may be more appropriate for clinical circumstances that occur over long durations, whereas specialist attribution may be preferred for episodes of shorter duration. Nonetheless, attribution to some specialists—such as oncologists and cardiologists—to manage disease over longer periods is clearly warranted.

Attribution models vary in their exclusivity: whether patients are attributed to one provider or multiple providers. Given the highly dispersive nature of care, the attribution of a patient to a single provider may not be equitable because it may fail to attribute patients to providers that have significant involvement in their care. Attribution to multiple providers acknowledges that many patients receive care from more than one provider and may more accurately reflect providers' actual patient pools. This approach can potentially foster greater levels of accountability for all patients rather than only patients with whom providers have established relationships. Nonetheless, the allowance of attribution to multiple providers was significantly less common among models uncovered in the environmental scan.

Incorporating requirements when making attributions attempts to ensure that patients are only attributed to providers that are responsible for their care. Higher thresholds such as majority or plurality rules are in some ways more favorable to providers because they restrict the attribution of patients with whom they have had limited contact. However, these rules may result in the attribution of fewer patients while excluding some that providers would consider as patients. As a result, requirements that are too strict may compromise the reliability of an approach. Overall, the appropriate requirement depends on what is being measured in an accountability program. For example, a PCP treating a diabetic patient should follow certain clinical guidelines regardless

of how many times he/she has seen a patient; however, attributing outcomes to a PCP who has seen a patient once may be unfair. In general, incorporating a majority rule may be appropriate for programs in which outcomes are assessed, but a one-touch rule may be more appropriate for an accountability program relying more on care that can be managed over a shorter interval. In some circumstances, it may also be fair to make providers responsible for care that occurs outside of their direct influence.

In conjunction with minimum requirements, many attribution approaches incorporate a specific measure to define greater involvement in patient care. The environmental scan revealed that visits and spending are the two most common measures used in this way. Although both are proxies for assessing the level of responsibility and influence of a provider on a patient, neither is necessarily proportional in terms of its impact on patient care. Visits, for example, can have different values for patients depending on the purpose and the services provided. In addition, spending disproportionately favors the attribution of patients to specialists even though they may have had limited involvement in the clinical decisions that led to spending (Leapfrog 2004). In an attempt to mitigate this challenge, a few models uncovered in the scan incorporated the attribution of Medicare patients using relative value units (RVUs) (Lake 2007; Weiner 1995). Although RVUs differentiate services according to their resource intensity, this approach may be less straightforward and would be unlikely to fully address the disadvantages of using visits or spending.

Finally, attribution approaches also vary in terms of the length of time that patients are assigned to providers. Because more care is provided as time goes on, longer time periods increase the ability to identify patterns of care and link patients to providers that have more involvement in their care. Longer patient-provider relationships may indicate greater levels of responsibility and

setting attribution lengths in this way may also encourage this form of care. Increasing the time period can also increase the number of patients that are assigned to providers, and thus increase the likelihood that attributed patients reflect their patient pool (AcademyHealth). However, because patients may not consistently see the same providers over longer periods of time, periods that are too long also introduce the risk of attributing patients that have only received low levels of care. Pham et al found that only 67% of patients were attributed to the same provider in the subsequent year.

Lessons from Attribution in Education

Much like health care, efforts to increase the quality of education in the United States have relied on accountability programs such as merit pay incentives and school performance rating programs. Although linking students to teachers or schools may seem fairly straightforward given the inherent enrollment process involved in education, attribution in education suffers from many of the same challenges as health care. For one, many students have more than one teacher for a single subject in a given year. Students may switch schools both within and between years. In addition, because academic gains are made over time and the effect of an individual teacher may not be immediate, attributing scores to a teacher who taught a student for one month might be unreasonable. Yet, there is no clear amount of instruction time a student must receive with a teacher to make an attribution fair. Further complicating attribution, a student's performance is influenced both by his/her previous teachers and current teachers of other subjects. As a result, a fifth grader's math scores could not only be attributed to the student's fifth grade math teacher but also other teachers like his/her fourth grade math and fifth grade English teachers. Different accountability programs have used various approaches in an attempt to address these challenges.

Pennsylvania Value Added Assessment System

The Pennsylvania System of School Assessment is a program that rates teachers and schools according to their impact on students' academic progress. As part of this program, teachers verify preliminary student rosters to ensure that all students are accurately attributed to teachers. Each individual student is then weighted according to the percent of instructional responsibility. This value takes into consideration the percent of days a student is enrolled in a teacher's class and the percent of content within a course that the teacher is responsible for (PVAAS 2014).

Denver Public Schools' Exceeds Expectations Program

The Exceeds Expectations Program is a system that awards bonuses to teachers on the basis of student growth percentiles. Students are attributed to teachers if they are enrolled for at least 85% of a course and in attendance at least 85% of the time. This approach was implemented in an effort to exclude students who have not had sufficient amounts of instructional time with teachers (CDE).

Tennessee Teacher Evaluation System

The Tennessee Teacher Evaluation System is an accountability program that uses a value-added approach to assess the impact of teachers on students' achievements. Students who are enrolled with a teacher for 150 days per year have 100% of their performance attributed to that teacher. Students who are enrolled for 75-149 days have 50% of their performance attributed to that teacher. Students enrolled for less than 75 days are not attributed to a teacher (Steele et al. 2010).

The strategy of using thresholds in both the Denver and Tennessee approaches mirrors that in health care. However, none of the models uncovered in the environmental scan use the partial or weighted attribution of patients to providers. Although determining how to weight patients would be challenging in practice, this strategy does have potential applications in health care. Incorporating the idea that some

patients continuously receive the majority of their care from a single physician and thus should be weighed more heavily than those who visit a provider once may help address some concerns surrounding current attribution approaches.

Section 5: Improving Attribution in Healthcare

The importance of attribution will only continue to grow: the Medicare Access and CHIP Reauthorization Act of 2015 (MACRA) legislation created unprecedented accountability for clinicians in Medicare. Under both the Merit-Based Incentive Payment System (MIPS) and Alternative Payment Model (APM) tracks, the terms under which patients are attributed to clinicians, provider organizations, and larger constellations of aligned provider groups will be central to the effort of providing effective and equitable incentives for quality and efficiency. Under these circumstances, numerous efforts have formed to understand the implications of attribution (Health Care Payment Learning Action Network 2016).

Our review suggests that there is a no single attribution approach that best meets the needs of all accountability programs. Factors such as the interests of the stakeholders, aims of the accountability program, and clinical circumstances influence the appropriateness of an attribution approach. The models identified through the environmental scan portray both the variety as well as the similarities in ways that approaches have been devised to address the uncertainty and instability in attribution. Although any attribution approach will inherently involve making tradeoffs, certain steps should be taken to improve current attribution models:

Data

Current attribution methods could benefit from better data surrounding the relationship between patients and providers. This will increase the ability of attribution methods to reflect the ways in which care is delivered as well as the ability to select

measures that are useful in the attribution process. Due to the limits in information, many models use proxies to make links between physicians and providers. For example, it is common among attribution approaches to use tax identifiers to differentiate between physicians or providers. Yet, physicians frequently bill under multiple tax identifiers and/or bill under tax identifiers that are at a group level, precluding the attribution of patients to individual providers (Damberg et al. 2009). Understanding the flaws of current methods as well as looking for appropriate alternatives can help strengthen attribution approaches.

Standardization

Even though the consistency of attribution approaches across all accountability programs is impractical, certain elements could be standardized. For example, several attribution models are designed around evaluation and management visits; however, there is no consistent way in which evaluation and management services are used to determine attribution (Damberg et al. 2009). Ensuring some standardization may increase clarity among providers and may also increase the ability to evaluate the effect of differences in attribution approaches as they are applied.

Patient and Provider Engagement

Attribution approaches could be improved by increasing the engagement of patients and providers. This includes not only incorporating their perspectives in the selection of a method, but also informing them of the details involved in the chosen method. The perspective on which approach is the best varies based on the interests of the stakeholders involved (Mehrotra et al. 2010). By engaging with patients and providers, accountability programs may be better positioned to balance competing interests and increase the responsiveness to programs.

Together, our analysis suggests the need to develop clear principles defining the use of attribution models in health care. These principles can be used to provide guidance to both measure developers and program planners regarding key considerations and trade-offs when specifying attribution approaches for accountability programs.

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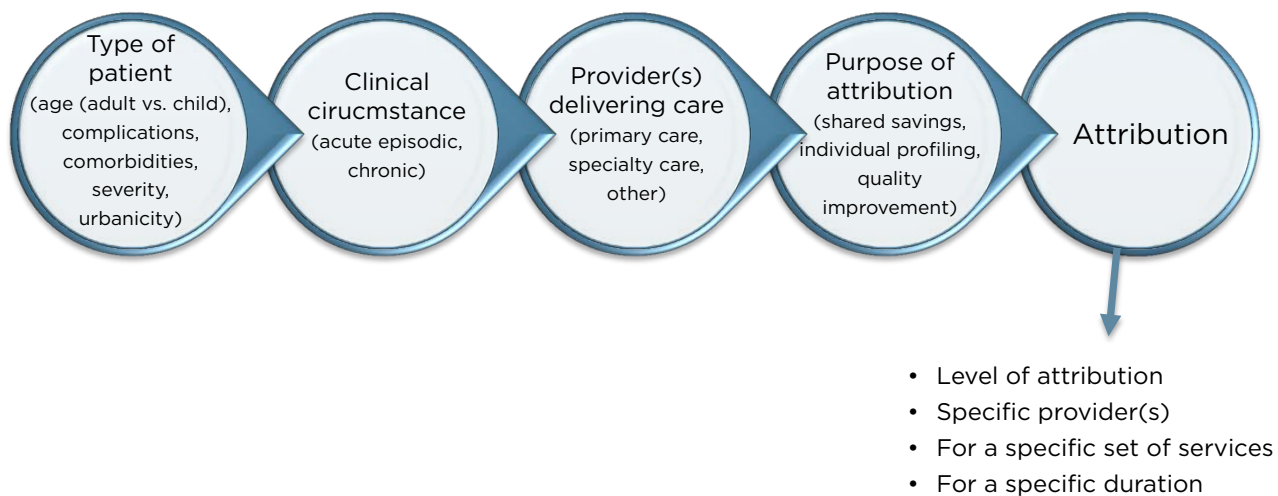
FIGURE F1. CONCEPTUAL MODEL OF ATTRIBUTION

- Level of attribution
- Specific provider(s)
- For a specific set of services
- For a specific duration

FIGURE F2. SCHEMATIC OF SEARCH STRATEGY 1: SEARCH REFERENCE LISTS OF RELEVANT ARTICLES

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┌────────────────────────────────┐
│ 15 Articles Selected: Describe │
│ attribution in different       │
│ settings and/or specific       │
│ attribution models             │
└────────────────────────────────┘
              │
              ▼
┌────────────────────────────────┐         ┌────────────────────────────────┐
│ 373 Articles:                  │         │ 83 Articles Excluded:          │
│ References for at least one of │ ──────▶ │ 67 Duplicates- References for  │
│ the 15 articles                │         │ more than one of the original  │
└────────────────────────────────┘         │ 15 articles                    │
              │                             │ 9 - Same as originals          │
              ▼                             │ 7 - Cited and reference        │
┌────────────────────────────────┐         └────────────────────────────────┘
│ 290 Articles Selected for      │
│ Title and Abstract Review      │         ┌────────────────────────────────┐
└────────────────────────────────┘ ──────▶ │ 253 Articles Excluded:         │
              │                             │ Non-English - 2                │
              ▼                             │ Not involving attribution - 251│
┌────────────────────────────────┐         └────────────────────────────────┘
│ 37 Articles Selected for       │
│ Detailed Review                │         ┌────────────────────────────────┐
└────────────────────────────────┘ ──────▶ │ 19 Articles Excluded:          │
              │                             │ Not describing a specific      │
              ▼                             │ attribution model              │
┌────────────────────────────────┐         └────────────────────────────────┘
│ 18 Articles Describing         │
│ Attribution Models             │
└────────────────────────────────┘
```

FIGURE F3. SCHEMATIC OF SEARCH STRATEGY 2: SEARCH ARTICLES THAT CITED RELEVANT ARTICLES

15 Articles Selected: Describe attribution in different settings and/or specific attribution models

862 Articles:
Cited at least one of the 15 articles

94 Articles Excluded:
Duplicates - cited more than one of the original 15 articles

768 Articles Selected for Title and Abstract Review

632 Articles Excluded:
Original Articles - 8
Non-English - 34
Not involving attribution - 610

116 Articles Selected for Detailed Review

64 Articles Excluded:
Not describing a specific attribution model

52 Articles Describing Attribution Models

FIGURE F4. SCHEMATIC OF SUPPLEMENTAL SEARCH STRATEGY: SEARCH PUBMED AND EMBASE

PubMed: 268 Hits

(attribut*[Title/Abstract]) OR assign*[Title/Abstract]) AND (delivery of health care[MeSH: noexp] OR quality of health care[MeSH: noexp] OR health care costs[MeSH: noexp] OR practice patterns, physicians[MeSH:noexp]) AND (accountable care organization*[Title/Abstract] OR value based purchasing[Title/Abstract] OR pay for performance[Title/Abstract] OR public report*[Title/Abstract] OR episode[Title/Abstract] OR profil*[Title/Abstract] OR tier*[Title/Abstract])

Embase: 944 Hits

attribut*:ab,ti OR assign*:ab,ti AND ('health care delivery'/de OR 'health care quality'/de OR 'health care cost'/de OR 'clinical practice'/de) AND ('accountable care organization':ab,ti OR 'value based purchasing':ab,ti OR 'pay for performance':ab,ti OR 'public report*':ab,ti OR episode:ab,ti OR profil*:ab,ti OR tier*:ab,ti)

222 Articles Excluded:
Duplicates and/or Previously Reviewed

990 Articles Selected for Title Review

909 Articles Excluded:
Non-English - 39
Not involving attribution - 870

81 Articles Selected for Detailed Review

67 Articles Excluded:
Not describing a specific attribution model

14 Articles Describing Attribution Models

TABLE F1. CHARACTERISTICS OF APPROACHES TO ATTRIBUTION DESCRIBED IN ENVIRONMENTAL SCAN (N=171)

Characteristic	Elements	N	Percentage
Program stage	Implemented	30	17.5%
	Proposed	141	82.5%
Type of provider attributed	ACO	18	10.5%
	Any physician	83	48.5%
	Hospital (Facility, clinic)	13	7.6%
	Other	5	2.9%
	PCP	27	15.8%
	PCP preferred	6	3.5%
	Physician group	15	8.8%
	Specialist	3	1.8%
	Unknown	1	0.6%
Timing of attribution	Other	8	4.7%
	Prospective	11	6.4%
	Retrospective	152	88.9%
Clinical Circumstances	All care	78	45.6%
	Chronic	20	11.7%
	Episodic	67	39.2%
	Other	6	3.5%
Payer/programmatic circumstances	Payer agnostic	29	17.0%
	Commercial payer	56	32.7%
	Demonstration	1	0.6%
	Medicaid	2	1.2%
	Medicare	74	43.3%
	Other	9	5.3%
Exclusivity of attribution	Patient is attributed to multiple providers	33	19.3%
	Patient is attributed to only one provider	133	77.8%
	Unknown	5	2.9%
Measure used to make attribution	Spending	52	30.4%
	Enrollment	2	1.2%
	Other	42	24.6%
	Unknown	2	1.2%
	Visit	73	42.7%
Minimum requirement to make attribution	Majority of care	24	14.0%
	"One Touch"	13	7.6%
	Other	33	19.3%
	Plurality of care	51	29.8%
	Plurality of care with Threshold (ex. 30%, 2 visits)	20	11.7%
	Threshold	28	16.4%
	Unknown	2	1.2%
Period of time for which provider is responsible for attributed patients	More than 1 year	50	29.2%
	One year	42	24.6%
	Other	67	39.2%
	Unknown	12	7.0%

TABLE F2. CHARACTERISTICS OF APPROACHES TO ATTRIBUTION DESCRIBED IN ENVIRONMENTAL SCAN FROM IMPLEMENTED MODELS (N=30)

Characteristic	Elements	N	Percentage
Program stage	Implemented	30	100.0%
	Proposed	0	0.0%
Type of provider attributed	ACO	13	43.3%
	Any physician	8	26.7%
	Hospital (Facility, clinic)	1	3.3%
	Other	2	6.7%
	PCP	1	3.3%
	PCP preferred	3	10.0%
	Physician group	2	6.7%
	Specialist	0	0.0%
	Unknown	0	0.0%
Timing of attribution	Other	4	13.3%
	Prospective	7	23.3%
	Retrospective	19	63.3%
Clinical circumstances	All care	20	66.7%
	Chronic	0	0.0%
	Episodic	8	26.7%
	Other	2	6.7%
Payer/programmatic circumstances	Payer agnostic	9	30.0%
	Commercial payer	13	43.3%
	Demonstration	1	3.3%
	Medicaid	2	6.7%
	Medicare	3	10.0%
	Other	2	6.7%
Exclusivity of attribution	Patient is attributed to multiple providers	4	13.3%
	Patient is attributed to only one provider	24	80.0%
	Unknown	2	6.7%
Measure used to make attribution	Spending	8	26.7%
	Enrollment	2	6.7%
	Other*	9	30.0%
	Unknown	0	0.0%
	Visit	11	36.7%
Minimum requirement to make attribution	Majority of care	3	10.0%
	"One Touch"	2	6.7%
	Other**	9	30.0%
	Plurality of care	10	33.3%
	Plurality of care with Threshold (ex. 30%, 2 visits)	3	10.0%
	Threshold	2	6.7%
	Unknown	1	3.3%
Period of time for which provider is responsible for attributed patients	More than 1 year	2	6.7%
	One year	9	30.0%
	Other***	11	36.7%
	Unknown	8	26.7%

Notes: * Some examples of "other" measures include: Attribution was made based on unspecified "services"; For some attribution models that spanned all programmatic circumstances, the measure used varied depending on whether beneficiaries were enrolled with a physician as part of their health plan; The model prioritized using either spending or visits to make an attribution, but used the other to resolve ties between two or more providers.

** Some examples of "other" minimum requirements include: Patients were enrolled with or designated a provider; For some attribution models that spanned all programmatic circumstances, the requirement used varied depending on whether beneficiaries were enrolled with a physician as part of their health plan

***The majority in the "other" category involved the attribution of episodes, in which case the duration of the attribution was dependent on the duration of the episode. A small number of models attributed patients for less than one year

TABLE F3. BIVARIATE RELATIONSHIP BETWEEN ATTRIBUTED PROVIDERS AND CHARACTERISTICS OF APPROACHES TO ATTRIBUTION FOR SELECT ATTRIBUTED PROVIDERS (N=149)

		Attributed provider					
		ACO		Any physician/ group		PCP/ PCP preferred	
Characteristic	Elements	N	Percentage	N	Percentage	N	Percentage
Program stage	Implemented	13	72.2%	10	10.2%	4	12.1%
	Proposed	5	27.8%	88	89.8%	29	87.9%
Timing of attribution	Other	2	11.1%	2	2.0%	3	9.1%
	Prospective	7	38.9%	2	2.0%	1	3.0%
	Retrospective	9	50.0%	94	95.9%	29	87.9%
Clinical Circumstances	All care	13	72.2%	34	34.7%	24	72.7%
	Chronic	0	0.0%	10	10.2%	4	12.1%
	Episodic	3	16.7%	53	54.1%	4	12.1%
	Other	2	11.1%	1	1.0%	1	3.0%
Payer/programmatic circumstances	Payer agnostic	0	0.0%	17	17.3%	10	30.3%
	Commercial payer	8	44.4%	37	37.8%	9	27.3%
	Demonstration	0	0.0%	1	1.0%	0	0.0%
	Medicaid	2	11.1%	0	0.0%	0	0.0%
	Medicare	7	38.9%	41	41.8%	12	36.4%
	Other	1	5.6%	2	2.0%	2	6.1%
Exclusivity of attribution	Patient is attributed to multiple providers	0	0.0%	23	23.5%	7	21.2%
	Patient is attributed to only one provider	16	88.9%	74	75.5%	26	78.8%
	Unknown	2	11.1%	1	1.0%	0	0.0%
Measure used to make Attribution	Spending	3	16.7%	41	41.8%	2	6.1%
	Enrollment	1	5.6%	0	0.0%	0	0.0%
	Other	9	50.0%	14	14.3%	10	30.3%
	Unknown	0	0.0%	1	1.0%	0	0.0%
	Visit	5	27.8%	42	42.9%	21	63.6%
Minimum requirement to make attribution	Majority of care	1	5.6%	17	17.3%	5	15.2%
	"One Touch"	1	5.6%	8	8.2%	4	12.1%
	Other	6	33.3%	8	8.2%	10	30.3%
	Plurality of care	8	44.4%	28	28.6%	10	30.3%
	Plurality of care with Threshold (ex. 30%, 2 visits)	0	0.0%	16	16.3%	1	3.0%
	Threshold	0	0.0%	21	21.4%	3	9.1%
	Unknown	2	11.1%	0	0.0%	0	0.0%
Period of time for which provider is responsible for attributed patients	More than 1 year	1	5.6%	25	25.5%	18	54.5%
	One year	8	44.4%	24	24.5%	8	24.2%
	Other	6	33.3%	47	48.0%	4	12.1%
	Unknown	3	16.7%	2	2.0%	3	9.1%

Note: Table does not include data from attributed hospitals, specialists, other providers, or unknown providers

TABLE F4. SUMMARY OF ATTRIBUTION APPROACHES FROM IMPLEMENTED MODELS IDENTIFIED IN THE LITERATURE SEARCH

Accountability Program	Description	Attribution Method	Related References
Accountable Care Organizations			
Alternative Quality Contract	A global payment contract for beneficiaries enrolled in Blue Cross Blue Shield of Massachusetts	Beneficiaries are prospectively attributed to a PCP by designating their PCP at the beginning of each year.	Song Z. Payment Reform in Massachusetts: Health Care Spending and Quality in Accountable Care Organizations Four Years into Global Payment. 2014. Doctoral Dissertation, Harvard University Medical School.
Children's Hospital and Clinics (CHC) of Minnesota	Medicaid ACO in the Twin Cities exclusively serving pediatric patients	Patients are retrospectively attributed to CHC based on: 1. whether they are in a healthcare home; or 2. where they received the plurality of their primary care.	1. Christensen EW, Payne NR. Effect of Attribution Length on the Use and Cost of Health Care for a Pediatric Medicaid Accountable Care Organization. JAMA Pediatr. 2016;170(2):148. doi:10.1001/jamapediatrics.2015.3446.; 2. Gleeson S, Brilli R. Does the Medical Home Really Matter? J Pediatr. 2016; 170: 14-16.
HealthCare Partners	Pilot ACO program for Anthem beneficiaries in California	Episodes are attributed to an ACO based on the plurality of allowed charges to either a primary care physician or a specialist.	Larson BK, Van Citters AD, Kreindler SA, et al. Insights from transformations under way at four Brookings-Dartmouth accountable care organization pilot sites. Health Aff (Millwood). 2012;31(11):2395-2406. doi:10.1377/hlthaff.2011.1219.; See also: Gbemundo JN, Larson BK, Van Critters AD, et al. HealthCare Partners: Building on a Foundation of Global Risk Management to Achieve Accountable Care. The Commonwealth Fund. 2012. Retrieved from http://www.commonwealthfund.org/~/media/Files/Publications/Case%20Study/2012/Jan/1572_Gbemudu_HealthCare_Partners_case%20study_01_17_2012.pdf.
		Attributions are also made prospectively based on historical care patterns- specifically, the plurality of outpatient evaluation and management visits.	
Medica	A regional health plan based in Minnesota that operates a shared savings contract	Patients are retrospectively attributed to a care system if they received 50% of primary care services from that system. Primary care is defined by place of service (office visits, or for those in the Medicaid product, emergency department visits) and the provider's specialty (internal medicine, general practice, family medicine, or OB/GYN).	Carlin C. Patient loyalty in a mature IDS market: is population health management worth it? Health Serv Res. 2014; 49(3): 1011-33.
Medicaid ACOs in Arkansas, Ohio, and Tennessee	Medicaid ACO programs	Episodes of perinatal care are retrospectively attributed to the health care provider who delivers a neonate. That provider is responsible for all perinatal care that occurred up to 40 weeks before delivery and care for 60 days postpartum.	Jarlenski M, Borrero S, La Charité T, Zite NB. Episode-based payment for perinatal care in medicaid. Obstet. Gynecol. 2016; 127(6):1080–84.
Medicare Shared Savings Program	Medicare ACO Program	A beneficiary is attributed to an ACO if the beneficiary receives the plurality of his or her primary care services from primary care practitioners (primary care physicians, nurse practitioners, clinical nurse specialists, physician assistants, or ACO professionals providing services at a FQHC/RHC) within the ACO.	1. Baseman S, Boccuti C, Moon M, Griffin S, Dutta T. Payment and Delivery System Reform in Medicare. Henry J. Kaiser Family Foundation. 2016. Retrieved from http://kff.org/medicare/ report/payment-and-delivery-system-reform-in-medicare-a-primer-on-medical-homes-accountable-care-organizations-and-bundled-payments/; 2. Hayen A. Incorporating shared savings programs into primary care: from theory to practice. BMC Heal Serv. 2015; 15:580.; See also: 1. Centers for Medicare and Medicaid Services. Medicare Shared Savings Program: Shared savings and losses and assignment methodology applicable beginning performance year 2016. CMS. 2015. Retrieved from https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/sharedsavingsprogram/Downloads/Shared-Savings-Losses-Assignment-Spec-V4.pdf 4; 2. MacKinney AC, Mueller KJ, Zhu X, Vaughn T. Medicare accountable care organizations: program eligibility, beneficiary assignment, and quality measures. Rural Policy Brief. 2014; 1–6.; This attribution model is applied and analzed in the following articles: 1. McWilliams JM, Chernew ME, Zaslavsky AM, Landon BE. 2013. Post-acute care and acos - who will be accountable? Health Serv. Res. 48(4):1526–38; 2. McWilliams JM, Chernew ME, Zaslavsky AM, Hamed P, Landon BE. 2013. Delivery system integration and health care spending and quality for medicare beneficiaries. JAMA Intern. Med. 173(15):1447; 3. Mukherji SK. 2014. The potential impact of accountable care organizations with respect to cost and quality with special attention to imaging. J. Am. Coll. Radiol. 2014; 11(4):391–96.
Monarch HealthCare	Pilot ACO program for Anthem beneficiaries in California	Episodes are attributed to an ACO based on the plurality of allowed charges to either a primary care physician or a specialist.	Larson BK, Van Citters AD, Kreindler SA, et al. Insights from transformations under way at four Brookings-Dartmouth accountable care organization pilot sites. Health Aff (Millwood). 2012;31(11):2395-2406. doi:10.1377/hlthaff.2011.1219.
		Attributions are also made prospectively based on historical care patterns- specifically, the plurality of outpatient evaluation and management visits.	
Norton HealthCare	Pilot ACO program for Humana beneficiaries in Kentucky	Patients are prospectively attributed to an ACO based on historical care patterns. Specifically, an attribution is made based on the plurality of outpatient evaluation and management visits.	Larson BK, Van Citters AD, Kreindler SA, et al. Insights from transformations under way at four Brookings-Dartmouth accountable care organization pilot sites. Health Aff (Millwood). 2012;31(11):2395-2406. doi:10.1377/hlthaff.2011.1219.

Accountability Program	Description	Attribution Method	Related References
Pioneer ACO	Medicare ACO program	The exact attribution method varies among Pioneer ACOs, however, each involves prospective attribution. Physicians are provided a list of patients in their ACOs. In some cases, ACOs may submit attestations from beneficiaries regarding their desire to be attributed to a provider. Beneficiary confirmations will be reflected in ACO alignment in the subsequent performance year.	1. Baseman S, Boccuti C, Moon M, Griffin S, Dutta T. Payment and Delivery System Reform in Medicare. Henry J. Kaiser Family Foundation. 2016. Retrieved from http://kff.org/medicare/ report/payment-and-delivery-system-reform-in-medicare-a-primer-on-medical-homes-accountable-care-organizations-and-bundled-payments/; 2. Dowd B, Kane R, Parashuram S. Alternative approaches to measuring physician resource use final report. CMS. 2012. Retreived from https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Reports/Downloads/ Alt_Approaches_Measuring_Phys_Res_Use_Report.pdf.; 3. Hsu J, Price M, Spirt J, Vogeli C. Patient Population Loss At A Large Pioneer Accountable Care Organization And Implications For Refining The Program. Health Aff. 2016; 35(3)- 422-30. 4. MacKinney AC, Mueller KJ, Zhu X, Vaughn T. Medicare accountable care organizations: program eligibility, beneficiary assignment, and quality measures. Rural Policy Brief. 2014; 1–6; 5. McWilliams JM, Chernew ME, Landon BE, Schwartz AL. 2015. Performance differences in year 1 of pioneer accountable care organizations. N. Engl. J. Med. 2015; 372(20):1927–36; 6. Schwartz AL, Chernew ME, Landon BE, McWilliams JM. Changes in low-value services in year 1 of the medicare pioneer accountable care organization program. JAMA Intern. Med. 2015; 175(11):1815
Tucson Medical Center	Pilot ACO program for United HealthCare beneficiaries in Arizona	Patients are prospectively attributed based on historical care patterns—specifically, the plurality of outpatient evaluation and management visits. Patients are also assigned based on the recency of outpatient primary care visits or pharmacy claims.	Larson BK, Van Citters AD, Kreindler SA, et al. Insights from transformations under way at four Brookings-Dartmouth accountable care organization pilot sites. Health Aff (Millwood). 2012;31(11):2395-2406. doi:10.1377/hlthaff.2011.1219.
Vermont ACO Pilot	An ACO developed through the collaboration of three health care providers and three commercial insurers in Vermont	Patients are prospectively attributed to an ACO based on their choice of PCP. In cases in which patients are not required to choose a PCP as part of their health insurance, patients are retrospectively attributed based on claims data over a two year period.	Hester J, Lewis J, McKethan A, Fund C. The Vermont Accountable Care Organization Pilot: A Community Health System to Control Total Medical Costs and Improve Population Health.; 2010. Retrieved from http://www.leg. state.vt.us/CommissionOnHealthCareReform/Hester_Vermont_aco_pilot CMWF_final.pdf.
Public Reporting Programs			
California Cooperative Healthcare Reporting Initiative	An initiative to collect and report standardized, reliable health plan and provider performance data in California	CCHRI has tested different methods of assigning patient events to physicians. One approach assigns denominator eligible patients to every physician of a relevant specialty for that measure who had at least one EM visit with the patient during the measurement period (i.e., one-touch rule). By the end of the project, the decision was made to align the numerator and attribution periods so that a physician must have seen the member for an EM visit during the time period in which they were to have received the numerator service.	Delmarva Foundation for Medical Care. Enhancing Physician Quality Performance Measurement and Reporting Through Data Aggregation: The Better Quality Information (BQI) to Improve Care for Medicare Beneficiaries Project. Delmarva Foundation for Medical Care. 2008. Retrieved from http:// www.wchq.org/measures/documents/BQI_Final_Report_10_2008.pdf.
California Physician Performance Incentive	A multi-stakeholder initiative to measure and report physician performance in California	A patient is retrospectively attributed to the single PCP with whom the patient had the most ambulatory/outpatient visits during the measurement year and the previous 1 year period. If the number of visits was equal for two or more PCPs, the patient is attributed to the physician that provided care during the most recent visit. For indicators that are relevant to specialists, patients are assigned to any specialist physician whom they saw during the attribution period. Patients can be attributed to more than one specialist for a given indicator. Patients without any visits or without a relevant specialist for a measure are not attributed. Patients are also attributed to "practice sites" (physicians of the same specialty who share the same practice address).	Cromwell J, Trisolini M G, Pope GC, Mitchell, JB, Greenwald LM. Pay for Performance in Health Care: Methods and Approaches. RTI Press Publication. 2011. Retrieved from www.rti.org/rtipress.

Accountability Program	Description	Attribution Method	Related References
Center for Health Information and Research	A regional database in Arizona that documents quality measurements	Patients are attributed to physicians using the following steps: 1. Physical exam or assessment performed by physician with allowed specialty (limited to selected specialties) and who is the PCP assigned via enrollment process. 2. Most recent physical exam or assessment performed by physician other than assigned PCP (limited to allowed specialties) 3. Physician who is in allowed specialty (other than the assigned PCP) and who performed largest number of EM type visits	Delmarva Foundation for Medical Care. Enhancing Physician Quality Performance Measurement and Reporting Through Data Aggregation: The Better Quality Information (BQI) to Improve Care for Medicare Beneficiaries Project. Delmarva Foundation for Medical Care. 2008. Retrieved from http://www.wchq.org/measures/documents/BQI_Final_Report_10_2008.pdf.
Indiana Health Information Exchange	A collaboration of hospitals, providers, researchers, public health organizations, and economic development groups in Indiana to improve health care quality and safety through information technology	In order to attribute the patient to a provider, IHIE created an algorithm that creates a rank ordered list of physician associations with the patient. IHIE then uses data about the providers including their specialty to identify the PCP. The current version of the algorithm relies on actual encounters that occurred (not appointments), laboratory results and prescriptions. Patients fall into one of several categories: A. Patients who have not had interactions with any providers B. Patients who have had interactions with only one provider that meets criteria to be a PCP C. Patients who have had interactions with multiple providers that meet criteria to be PCPs.	Delmarva Foundation for Medical Care. Enhancing Physician Quality Performance Measurement and Reporting Through Data Aggregation: The Better Quality Information (BQI) to Improve Care for Medicare Beneficiaries Project. Delmarva Foundation for Medical Care. 2008. Retrieved from http://www.wchq.org/measures/documents/BQI_Final_Report_10_2008.pdf.
Massachusetts Health Quality Partners	A quality measurement and public reporting program in Massachusetts	Patients in managed care insurance were attributed to the PCP whom the health plan assigned to the patients. For patients in PPO and Medicare FFS products to the PCP who had the highest volume of EM office visits with that patient in the 18 months before the end date of the measurement period. For PPO/FFS patients with no visits to a PCP in the specified measurement period, MHQP attributed care to a visited specialist relevant to the quality indicator (e.g., a cardiologist for cardiac measures).	1. Cromwell J, Trisolini M G, Pope GC, Mitchell, JB, Greenwald LM. Pay for Performance in Health Care: Methods and Approaches. RTI Press Publication. 2011. Retrieved from www.rti.org/rtipress.; 2. Delmarva Foundation for Medical Care. Enhancing Physician Quality Performance Measurement and Reporting Through Data Aggregation: The Better Quality Information (BQI) to Improve Care for Medicare Beneficiaries Project. Delmarva Foundation for Medical Care. 2008. Retrieved from http://www.wchq.org/measures/documents/BQI_Final_Report_10_2008.pdf.

Accountability Program	Description	Attribution Method	Related References
Minnesota Community Measurement	A statewide public quality reporting initiative	Each member in the eligible population for each measure is attributed to one Medical Group for the measurement year based on claims/encounter data for selected services (EM codes and Preventive codes) received in that measurement year. For non-diabetes measures, patients are attributed to group with the highest number of EM claims/encounters if those claims/encounters are associated with the following specialties: general practice, family practice, internal medicine, pediatrics, geriatric medicine, obstetrics and gynecology, cardiology, physician assistant, nurse practitioner. If there is a tie between a primary care and specialist provider, the group with primary care visit is preferred. If there is a tie between 2 PCPs, a patient is attributed to the one with the most recent date of service. Primary Care is defined as general practice, family practice, internal medicine, pediatrics, geriatric medicine, physician assistant, and nurse practitioner. For those members that have claims/encounters that are not associated with one of the specialties listed above, they are assigned to Medical Group 0 (zero). For diabetes measures, members that are not attributed to a medical group using the above steps, they are attributed based on the highest number of EM or diabetes claims/encounters (i.e., maximum frequency rule) during the measurement year regardless of specialty.	Delmarva Foundation for Medical Care. Enhancing Physician Quality Performance Measurement and Reporting Through Data Aggregation: The Better Quality Information (BQI) to Improve Care for Medicare Beneficiaries Project. Delmarva Foundation for Medical Care. 2008. Retrieved from http://www.wchq.org/measures/documents/BQI_Final_Report_10_2008.pdf.
Wisconsin Collaborative for Healthcare Quality	A quality reporting initiative covering over 40 physician groups, hospitals, and health plans in Wisconsin	Members of this initiative self-determine responsibility for their patients based on three questions: For disease-specific measures: 1) Is this a patient with the disease or condition? – Patients require a defined number of office visits for their condition to qualify for the measure. 2) Is this patient whose care is managed within the physician group? Patients are required to be managed by the physician group in order to be eligible for the measure. 3) Is this a patient currently managed in our system – Patients must be currently managed by the physician group in order to be included in the measure. For other measures: 1) Is this a patient we manage? - Patients are required to be managed by the physician group in order to be eligible for the measure. 2) Is this a patient that is current in our system? Patients must be currently managed by the physician group in order to be included in the measure. 3) Is this a patient that is eligible for the measure? – Patients who meet the defined measure eligibility criteria	1. Delmarva Foundation for Medical Care. Enhancing Physician Quality Performance Measurement and Reporting Through Data Aggregation: The Better Quality Information (BQI) to Improve Care for Medicare Beneficiaries Project. Delmarva Foundation for Medical Care. 2008. Retrieved from http://www.wchq.org/measures/documents/BQI_Final_Report_10_2008.pdf.; 2. Greer A. Embracing Accountability: Physician Leadership, Public Reporting, and Teamwork in the Wisconsin Collaborative for Healthcare Quality. The Commonwealth Fund. 2008. Retrieved from http://www.commonwealthfund.org/~/media/files/publications/fund report/2008/jun/embracing accountability physician leadership public reporting and teamwork in the wisconsin coll/greer_embracingaccountabilitywisconsincollab_1142 pdf.pdf.

Accountability Program	Description	Attribution Method	Related References
Value-based Purchasing/ Pay-for-Performance			
Medicare Physician Group Practice Demonstration Project	A 5-year P4P initiative that incentivized physician group to coordinate the care they provided to Medicare beneficiaries	Beneficiaries were retrospectively assigned to the practice group that provided the plurality of office or other outpatient evaluation and management services during the performance year.	1. Centers for Medicare & Medicaid Services. PGP fact sheet. CMS. 2009. Retrieved from http://www. cms.gov/Medicare/Demonstration-Projects/ DemoProjectsEvalRpts/downloads//PGP_ Fact_Sheet.pdf ; 2. Kautter J, Pope GC, Trisolini M, Grund S. Medicare Physician Group Practice Demonstration design: Quality and efficiency pay-for- performance. Health Care Financing Review. 2007; 29(1): 15–29.; 3. Pope GC, Trisolini M, Kautter J, Ada- manche W. Physician Group Practice (PGP) demonstration design report. CMS. 2002.; 4. Cromwell J, Trisolini M G, Pope GC, Mitchell, JB, Greenwald LM. Pay for Performance in Health Care: Methods and Approaches. RTI Press Publication. 2011. Retrieved from www.rti.org/rtipress.; 4. McKethan A. Improving Quality and Value in the US: Health Care System. Bipartisan Policy Center. 2009. Retreived from: http://bipartisanpolicy.org/wp-content/uploads/sites/ default/files/BPC8-09-PCHC%20Qual%20rpt-8-20-09.pdf; 5. Schneider E, Hussey PS, Schnyer C. Payment Reform. RAND Health. 2011. Retrieved from http://s3.amazonaws.com/rdcms-himss/files/production/public/ HIMSSorg/Content/files/RANDReportMeasurementImplicationsPerforamn ce-BasedPaymentReformModels.pdf.; 5. Kautter J, Pope G, Leung M, Trisolini M, Adamache W, Smith K. Financial and quality impacts of the medicare physician group practice demonstration. Medicare Medicaid Res. Rev. 2014; 4(3):E1–22.
Physician Value-Based Payment Modifier	This program began in 2015 and offers differential payments to physicians and physician groups on the basis of the quality and value of care provided to attributed beneficiaries during a performance period	Beneficiaries are retrospectively attributed to the group that provides the plurality of primary care services. Primary care services include office-based, home health, or nursing home evaluation and management codes as well as other codes defined by CMS. Certain large single specialty groups – such as those limited to emergency medicine, diagnostic radiology, pathology, and anesthesiology – may not be attributed any beneficiaries under this attribution methodology	Centers for Medicare & Medicaid Services. Summary of 2015 Physician Value-based Payment Modifier Policies. CMS. 2013. Retrieved from http://www.cms.gov/ Medicare/Medicare-Fee-for-Service-Payment/ PhysicianFeedbackProgram/Downloads/ CY2015ValueModifierPolicies.pdf
Physician Profiling and Network Tiering			
Aetna	This approach relates to Aetna's method for attributing patients for purposes such as network tiering, providing physicians with feedback report, and public reporting	Episodes are assigned to physician with majority of claims dollars included in the episode, or to surgeon if a surgery occurs.	Lake T, Colby M, Peterson S. Health Plans' Use of Physician Resource Use and Quality Measures. Mathematica Policy Research. 2007. Retrieved from https:// www.mathematica-mpr.com/our-publications-and-findings/publications/ health-plans-use-of-physician-resource-use-and-quality-measures.
		Episodes are assigned to each physician with more than 20% of claims dollars included in the episode.	
Blue Cross/Blue Shield	This approach relates to Blue Cross/Blue Shield's method for attributing patients for purposes such as network tiering, providing physicians with feedback report, and public reporting	Episode assigned to physician who bills the greatest total Relative Value Units (RVUs) for a given episode, as long as the physician has a minimum number of RVUs. When no physician is identified by RVUs, episode is attributed to the physician billing the greatest number of outpatient evaluation or management services for the episode, as long as the physician has a minimum number of outpatient EM services. When no physician is identified by either of the above, episode is attributed to the physician with the highest allowable cost included in the episode.	Lake T, Colby M, Peterson S. Health Plans' Use of Physician Resource Use and Quality Measures. Mathematica Policy Research. 2007. Retrieved from https:// www.mathematica-mpr.com/our-publications-and-findings/publications/ health-plans-use-of-physician-resource-use-and-quality-measures.
Clinical Performance Improvement (CPI) Initiative	An initiative In Massachusetts that involves the construction a consolidated, multi-plan claims database to develop cost-efficiency and quality of care profiles for physicians that can be used by health plans to partition their physician networks into preferred and non-preferred tiers.	Episode responsibility is attributed to the physician accounting for the highest portion of professional cost in the episode, so long as the physician's portion equals at least 25%. Ideally, episode responsibility should reflect all costs – professional, inpatient, outpatient, and pharmacy	Green RA, Beckman HB, Patridge GH, Thomas JW. Review of the Massachusetts Group Insurance Commission Physician Profiling and Network Tiering Plan: a report to the Massachusetts Medical Society. Massachusetts Medical Society. 2006. Retrieved from http://www.massmed. org/AM/Template.cfm? Section=Pay_for_Performance&TEMPLATE=/CM/ ContentDisplay. cfm&CONTENTID=16760; See also: Alteras T, Silow-Carroll S. Value-driven health care purchasing: a case study of the Massachusetts group insurance commission. The Commonwealth Fund. 2007. Retrieved from http://www.commonwealthfund.org/usr_doc/1053_Alteras_value-driven_ Massachusetts_case_study.pdf.

Accountability Program	Description	Attribution Method	Related References
Harvard Pilgrim Health Care	This approach relates to Harvard Pilgrim Health Care's method for attributing patients for purposes such as network tiering, providing physicians with feedback report, and public reporting	Episodes are assigned to physician with the highest amount of claims dollars, as long as physician is responsible for at least 25% of the episode fees charged. If no physician has at least 25% of the claims dollars for the episode, the episode remains unassigned.	Lake T, Colby M, Peterson S. Health Plans' Use of Physician Resource Use and Quality Measures. Mathematica Policy Research. 2007. Retrieved from https://www.mathematica-mpr.com/our-publications-and-findings/publications/health-plans-use-of-physician-resource-use-and-quality-measures.
United HealthCare	This approach relates to United Health Care's method for attributing patients for purposes such as network tiering, providing physicians with feedback report, and public reporting	For non-proceduralists, episodes are assigned to the physician with the majority of claims dollars included in the episode .For proceduralists, episodes are assigned to physician who submitted the claim for the interventional procedure.	Lake T, Colby M, Peterson S. Health Plans' Use of Physician Resource Use and Quality Measures. Mathematica Policy Research. 2007. Retrieved from https://www.mathematica-mpr.com/our-publications-and-findings/publications/health-plans-use-of-physician-resource-use-and-quality-measures.
Patient-Centered Medical Home			
Medical Services Initiative	A patient-centered medical home initiative for low-income, uninsured patients in Orange County, California	Patients are prospectively attributed to a medical home (clinic or private physician) at the time of enrollment based on choice or assignment. Within clinic-based medical homes, the enrollee chooses or is assigned to a specific physician to serve as their personal provider. This decision may be based on personal relationships, recommendation, language spoken by the provider, or proximity to the enrollee's home. This medical home is intended as the source for all primary care.	Roby DH, Pourat N, Pirritano MJ, Vrungos SM, Dajee H, et al. Impact of patient-centered medical home assignment on emergency room visits among uninsured patients in a county health system. Med. Care Res. Rev. 2010; 67(4):412–30.
Minnesota's Health Care Home Initiative	An statewide initiative in Minnesota to incentivize PCPs to provide comprehensive care to their members through a medical home model	PCPs are assigned clinics using an algorithm that considers the Statewide Quality Reporting and Measurement system registry. Patients are then retrospectively attributed to clinics based on an algorithm that considers: 1. the clinic that associated with the provider in which they had the greatest number of EM encounters; 2.the number of clinic encounters that are with an MD/DO, NP, or PA; 3. date of most recent visit to clinic. In order to make an attribution, at least 10% of an enrollee's professional service encounters must be with the clinic.	Wholey D, Finch M, Shippee ND, et al. Evaluation of the State of Minnesota's Health Care Home Initiative: Evaluation Report for years 2010-2012. Minnesota Department of Health. 2014. Retrieved from http://www.health.umn.edu/sites/default/files/UM 2015 HCH Evaluation Final 07Feb2016.pdf.

TABLE F5. SUMMARY OF ATTRIBUTION APPROACHES FROM PROPOSED MODELS IDENTIFIED IN THE LITERATURE SEARCH

Citation	Description	Attribution Method
Attribution of Episodes of Care		
Adams JL, McGlynn EA, Thomas JW, Mehrotra A. Incorporating Statistical Uncertainty in the Use of Physician Cost Profiles. BMC Health Serv Res. 2010; 10:57.	This study utilizes data from four commercial insurers in Massachusetts to analyze methods to develop physician cost profiles for the purpose of public reporting and quality improvement.	Using claims data, each episode of care was retrospectively attributed to the physician who had billed the greatest fraction (at least 30%) of the professional costs related to the episode. Physicians were then categorized as low cost, average cost, or high cost.
Halpern R, Kothari S, Fuldeore M. GERD-related health care utilization, therapy, and reasons for transfer of GERD patients between primary care providers and gastroenterologists in a US managed. Dig Dis Sci. 2010; 55(2):328-337.	This article analyzes health care utilization among patients with gastroesophageal reflux disease treated by PCPs and gastroenterologists.	Episodes were categorized as PCP if at least 55% of GERD-related utilization, including office visits, procedures, and GERD medication fills, was associated with a PCP physician (general practitioner, family practitioner or internal medicine). Episodes were classified as GE if at least 55% of GERD-related utilization was associated with a GE specialty code. All remaining episodes were classified as "other;" these episodes were characterized by specialty codes associated with ear, nose, and throat, emergency medicine, general surgery, and facilities
Huckfeldt P, Chan C, Hirshman S, Kofner A. Specialty Payment Model Opportunities and Assessment. CMS Alliance to Modernize Healthcare. 2015. Retrived from http://www.rand.org/content/dam/rand/pubs/research_reports/RR700/RR763/RAND_RR763.pdf.	This report examines the use episode-based payment models for oncology care.	Patient episodes were attributed to practices using two strategies: 1. Retrospective attribution based on the plurality of cancer-related visits for EM services over a 60 day period that was preceded by a 30 day period in which no cancer-related claims were reported. In cases of ties, the measurement period was extended for an additional 90 day period.
		2. Prospective attribution to the practice responsible for the trigger chemotherapy claim (i.e., the claim that is used to identify the initiation of the chemotherapy treatment episode). Attribution using an EM claim on the same day as trigger event was prioritized followed by the practice billing the greatest number of EM visits on the same day as a claim for a chemotherapy drug. The measurement period window was extended in the case of ties. Episodes were attributed to physicians in the hospital outpatient department if no other attribution could be made.
Ingenix. Symmetry episode treatment groups: Issues and best practices in physician episode attribution. 2007. Retrieved from https://etg.optum.com/Ingenix/Media/ETG/Symmetry_EpisodeAttribution_WP_FINAL_112007_L01.pdf.	This white paper examines different approaches and identifies best practices for attributing episodes to providers	This paper evaluates the following attribution approaches: 1. Physician Episode Attribution Using Professional Service Costs: This attribution approach identifies the responsible physician for an episode as that provider rendering the greatest amount of professional service costs during the episode
		2. Physician Episode Attribution Using Episode Clusters: This attribution approach identifies the responsible physician for an episode as that provider in the peer group owning the greatest number of "clusters" within the episode.
		3. Physician Episode Attribution Using Non-Acute EM Visits: This attribution approach identifies the responsible physician for an episode as that physician providing the greatest number of non-acute EM visits within the episode.
		4. Physician Episode Attribution Using a Primary Care, Population-based Approach: Responsibility for a member's qualified episodes of care may be attributed to the member's PCP—whether or not the PCP provided any of the services for that member during those episodes.
MaCurdy T, Theobald N, Kerwin J, Ueda K. Prototype Medicare Resource Utilization Report Based on Episode Groupers. Acumen, LLC. 2008. Retrieved from https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Reports/downloads/MaCurdy2.pdf.	This report provides recommendations to CMS on the attribution of episodes to providers for the purpose of examining physician resource utilization	This paper evaluates the following attribution approaches: 1. Beneficiaries are attributed to the provider associated with the greatest number of Part B costs. If there are no positive costs on Part B claims assigned to an episode, then the episode is not attributed to a provider. In the case where the payments from Part B claims to two or more providers are equal, then the next rule applied breaks the tie between the providers by attributing the episode the provider with the highest costs from EM claims
		2. Beneficiaries are attributed to the provider with the most EM charges. When there is a tie in EM costs among providers, it is broken by attributing the episode to the provider with the highest Part B costs. If both EM and Part B costs are tied among providers, then the algorithm moves to numbers of EM claims followed by numbers of Part B claims.

Citation	Description	Attribution Method
MedPAC. Using episode groupers to assess physician resource use. Report to the Congress: Increasing the Value of Medicare. 2006. Retrieved from http://www.medpac.gov/documents/reports/Jun06_EntireReport.pdf?sfvrsn=0.	This report discusses different approaches for attributing episode to providers to assess physician resource use	This report examines the following approaches: Percentage of Evaluation and Management Visits, single provider: 1. 30%
		2. 35%
		3. 40%
		4. 50%
		Percentage of non-inpatient EM visits, single provider: 5. 30%
		Percentage of EM dollars, single provider: 6. 30%
		7. 35%
		8. 40%
		9. 50%
		Multiple provider, attribution by visits: 10. 35%
Mehrotra A, Adams J, Thomas J, McGlynn E. Cost profiles: should the focus be on individual physicians or physician groups? Health Aff (Millwood). 2010; 29(8):1532-8.	This article assesses approaches for developing physician cost profiles.	Beneficiaries receiving at least one primary care service from a PCP (defined by specialty codes for general practice, family practice, internal medicine, or geriatric medicine) were retrospectively assigned based on primary care services provided by PCPs. Beneficiaries with multiple primary care services were assigned to the ACO in which they had the greatest outpatient spending. Beneficiaries receiving no primary care services from a PCP were assigned based on primary care services provided by physicians of other specialties, nurse practitioners, or physician assistants. Beneficiaries receiving no primary care services were not assigned.
Mehrotra A, Liu H, Adams J. The costs and quality of care for three common illnesses at retail clinics as compared to other medical settings. Ann Intern Med. 2009; 151(5): 321-328.	This article examines the quality of care at retail clinics compared to other health facilities.	The total cost of an episode of care was attributed to the physician who accounted for the highest fraction (minimum 30%) of professional costs within the episode. If the physician worked in a group, the episodes assigned to a physician were also assigned to this group.
Metfessel B, Greene R. A nonparametric statistical method that improves physician cost of care analysis. Health Serv Res. 2012; 47(6): 2398-417.	This article analyzes methods to develop physician cost profiles using episode treatment groups.	Episodes were retrospectively attributed to provider facilities according to the location of the first EM visit in the episode: retail clinic, physician office, urgent care clinic, or emergency department.
Nyman M. Inclusion of short-term care patients affects the perceived performance of specialists: a retrospective cohort study. BMC Health Serv Res. 2015; 15:99.	This articles looks at how difference in quality measurement period length impact quality performance profiles for specialists.	Each episode was attributed to the single physician who generated the highest percentage of costs in an episode. Only episodes in which a physician was responsible for at least 30% of costs were attributed.
Sandy LG, Rattray MC, Thomas JW. Episode-based physician profiling: a guide to the perplexing. J Gen Intern Med. 2008; 23 (9): 1521-1524. 10.1007/s11606-008-0684-z.	This articles discusses the strengths and limitations of episode-based provider profiling.	This paper evaluates the following attribution approaches: 1. Episodes were assigned to the physician who accounted for 30% or more of professional and prescribing costs included in the episode.
		2. Episodes were attributed to a physician in a relevant specialty (e.g., internal medicine, endocrinology) who had the largest number of EM encounters during the profiling period.
National Quality Forum. National Voluntaty Consensus Standards for Cost and Resource Use. 2012. Retrieved from www.qualityforum.org/Publications/.../Cost_and_Resource_Use_Final_Report.aspx	This report provides recommendations on combining resource use data and quality to promote efficiency in health care.	This report outlines several attribution approaches that can be applied to 1. Physician Episode Attribution using Professional Service Costs. This attribution approach identifies the responsible physician for an episode as that provider rendering the greatest amount of professional service costs during the episode.
		2. Physician Episode Attribution using Episode Clusters. This attribution approach identifies the responsible physician for an episode as that provider in the peer group owning the greatest number of "clusters" within the episode.
		3. Physician Episode Attribution using Non-Acute EM Visits. This attribution approach identifies the responsible physician for an episode as that physician providing the greatest number of non-acute EM visits within the episode.
		4. Physician Episode Attribution using a Primary Care, Population-based Approach. This approach requires two important steps: 1) Identification of a PCP for each member. 2) Identify the patient's assigned PCP during the episode period.
Thomas JW, Ward K. Economic profiling of physician specialists: use of outlier treatment and episode attribution rules. Inquiry. 2006;43(3):271–282.	This article analyzes methods to attribute patients to physician in order to develop economic profiles.	Episodes were retrospectively assigned to one or more physicians using one of the following approaches:1. 20% rule- 20% or more of professional and prescribing costs for an episode
		2. 30% rule- 30% or more of professional and prescribing costs for an episode
		3. 50% rule- 50% or more of professional and prescribing costs for an episode.

Citation	Description	Attribution Method
Timbie J, Hussey P, Adams J. Impact of socioeconomic adjustment on physicians' relative cost of care. Med Care. 2013; 51(5): 454-60.	This study examines the impact of socioeconomic status adjustment on episode-based physician cost profiling.	Episodes of care and their associated costs were retrospectively attributed to the physician having a plurality of professional costs (subject to a minimum of 30 percent of total professional costs) within the episode.
Attributing Patients to Hospitals, Physician Networks, or ACOs		
Anderson L, Flottemesch T. Patient medical group continuity and healthcare utilization. Am J Manag Care. 2012; 18(8): 450-7.	This article analyzes the continuity of care over a 5 year period among patients insured by HealthPartners.	Patients were retrospectively attributed using claims data to the medical group where they had the greatest number of primary care visits. In case of ties, patients were attributed to the medical group where the most recent visit occurred. Primary care visits were defined by location and specialty of the billing physician and included the following specialties: family medicine, internal medicine, pediatrics, geriatrics, and obstetrics and gynecology. Nurse practitioner and physician assistant visits were also included. Patients without primary care visits in a year were not attributed in that year.
Bynum JPW, Bernal-Delgado E, Gottlieb DJ, Fisher ES. Assigning ambulatory patients and their physicians to hospitals: a method for obtaining population-based provider performance measurements. Health Serv Res. 2007;42(1):45–62.	This study analyzes the validity of using claims data to assign Medicare FFS beneficiaries to physicians and hospitals for the purpose of developing population-based estimates of provider costs and quality.	Patients were retrospectively assigned to their predominant ambulatory physician. This was defined as the generalist (internist, geriatrician, family, or general practitioner) or specialist with whom the patient had the most ambulatory visits during the 2 years after an index visit to any provider in 1998. If there were no visits to generalists or specialists, patients were assigned to other physician types (e.g., dermatologists or surgeons). If the number of visits to physicians of equal priority was tied, the physician with the greatest time span between the first and last visits was chosen to favor longitudinal patient–physician relationships. If a patient had only one visit to each, then the most recent was chosen.
Everett C, Thorpe C. Division of primary care services between physicians, physician assistants, and nurse practitioners for older patients with diabetes. Med Care Res Rev. 2013; 70(5):531-41.	This study analyzes the division of services between PCPs for Medicare patients with diabetes.	Patients were first assigned to the primary care clinic that provided the majority of their face-to-face visits, then to the provider (physician or PA/NP) that delivered the majority of visits within that clinic. In the event of a tie, patients were assigned to the clinic/provider with the most recent visit. Patient panels grouped patients assigned to the same usual provider of care within a clinic.
Fisher ES, Staiger DO, Bynum JPW, Gottlieb DJ. Creating accountable care organizations: the extended hospital medical staff. Health Aff (Millwood) 2007;26(1):w44–57. DOI: 10.1377/hlthaff.26.1.w44.	This study analyzes whether it is feasible to use hospitals and their extended medical staff as the locus of performance assessment and accountability	Patients and physicians were assigned to hospitals using a three-year period of claims data. 60% of physicians were assigned to the hospital where they provided care to the greatest number of inpatients. Physicians who did not treat inpatients were assigned to hospitals according to where the plurality of their patients were admitted. Patients were assigned to the physicians who provided the most ambulatory care. Patients were then assigned to hospitals on the basis of their physicians' designation. Secondary hospitals were defined as the single other hospital most frequently used by a primary hospital's ambulatory cohort.
Hirth R, Turenne M. Provider Monitoring and Pay-for-Performance When Multiple Providers Affect Outcomes: An Application to Renal Dialysis. Heal Serv Res. 2009; 44(5.1): 1585-602.	This study analyzes the affect of dialysis facilities and nephrologists resource use on patient outcomes.	Patients were retrospectively attributed to providers and facilities using the unique physician identification number code reported on dialysis claims. Patients could be attributed to more than physician and/or facility.
Lewis VA, McClurg AB, Smith J, Fisher ES, Bynum JP. Attributing patients to accountable care organizations: performance year approach aligns stakeholders' interests. Health Aff (Millwood). 2013;32(3):587-95.	This study evaluates approaches for defining the patient population of Medicare ACOs by simulating the formation of ACOs based on Medicare FFS claims data.	The study compared the following two approaches: Prospective-Patients' use of service in the previous year was used to prospectively assign patient to providers during the performance year
		Performance Year- Patients were retrospectively attributed to providers on the basis of their service utilization during the performance year period The study also varied inclusion specifications such as only attributing patients to PCPs.
		Patients were then assigned to the hospital where their physician provided inpatient services or where a plurality of that physician's patient panel had medical admissions.
McWilliams J. Outpatient care patterns and organizational accountability in Medicare. JAMA Intern Med. 2014; 174(6): 938-45.	This article uses Medicare claims data to assess the capacity of hypothetical ACOs.	Beneficiaries were attributed to the ACO that provided the accounted for the greatest proportion of outpatient primary care spending.
Pollack C, Bekelman J, Liao K, Armstrong K. Hospital racial composition and the treatment of localized prostate cancer. Cancer. 2011; 117(24): 5569-78.	This study investigates racial differences in the treatment of men with prostrate cancer.	1. Patients were attributed to the hospital from which they had the most distinct visits
		2. Patients were also attributed to the first hospital where they were seen either on their date of diagnosis or the first hospital in which they were seen after the date of diagnosis

Citation	Description	Attribution Method
Pollack C, Weissman G. Physician social networks and variation in prostate cancer treatment in three cities. Heal Serv Res. 2012; 47(1.2): 380-403.	This study analyzes physician networks and whether they are associated with variations in prostate cancer treatment.	In order to construct physician networks, patients were attributed to several providers:1. Diagnosing urologist. The urologist who billed for a claim on the date of the patient's diagnosis. If no claim was submitted, the patient was attributed to the urologist who saw the patient nearest to the date of diagnosis in the 3 months prior. If no urologist was identified, attribution was made to the urologist who saw the patient nearest to the date of diagnosis in the 3 months following diagnosis.
		2. Majority urologist was defined as the urologist who billed for claims on the most days in the 9 months following diagnosis.
		3. PCP was defined as the internal medicine (without subspecialty training), family practice, or general practice physician who billed for the greatest number of visits.
		4. Plurality provide- Patients were attributed to doctors who billed for the greatest numbers of EM visits in the 12 months prior to the date of diagnosis, regardless of their clinical specialty.
		5. Radiation oncologists. For patients who underwent external beam radiation and brachytherapy, attribution was also made to the provider who performed the clinical planning and simulation.
Attribution Using Statistical Modeling		
Atlas SJ, Chang Y, Lasko TA, Chueh HC, Grant RW, Barry MJ. Is This "My" Patient? Development and Validation of a Predictive Model to Link Patients to Primary Care Providers. Journal of General Internal Medicine. 2006;21(9):973-978. doi:10.1111/j.1525-1497.2006.00509.x.	In this study, 18 PCPs from MGHN reviewed patient records and designated each patient as "My Patient" or "Not My Patient" in order to develop and validate an approach to link patients to PCPs.	PCPs retrospectively attributed patients to their patient panel by reviewing all records for outpatient visits over a 3 year period. This information was then used to develop an algorithm with logistic regression modeling to attribute patients to providers. The model contained the following variables: PCP designee in registration field, physician practice style, patient age, months since last visit with physician, and patient's residence listed as in state.
Atlas S, Grant R, Ferris T. Patient–physician connectedness and quality of primary care. Ann Intern Med. 2009; 150(5): 325-35.	This article analyzes whether patient connectedness influences measures of physician performance.	The following steps were used to attribute patients to providers: 1. Patient registered with a MGH PCP, 2. Patient had at least one visit to PCP, 3. Patients connected through algorithm. In cases, where a patients was registered with and visited a resident, patients were attributed to a practice group.
Lasko TA, Atlas SJ, Barry MJ, Chueh HC. Automated identification of a physician's primary patients. J Am Med Inform Assoc. 2006;13:74–9.	In this study, 18 PCPs from MGHN reviewed patient records and designated each patient as "My Patient" or "Not My Patient" in order to develop and validate an approach to link patients to PCPs.	PCPs retrospectively attributed patients to their patient panel by reviewing all records for outpatient visits over a 3 year period. This information was then used to develop an algorithm with logistic regression modeling to attribute patients to providers. The model contained the following variables: waiting fraction, visit difference, days since last visit, idle ratio, practice style, and future difference.
Attribution in International Contexts		
Kang HC, Hong JS. Do differences in profiling criteria bias performance measurements? Economic profiling of medical clinics under the Korea National Health Insurance program: An observational study using claims data. BMC Health Serv Res. 2011; 11: 189.	This study analyzes how differences in two case-mix classification systems influence the calculation of cost-efficiency indexes for outpatient clinics in South Korea	1. Korean Classification of Diseases- All cases were attributed to clinics. Patients were classified using a 3 digit disease code and subdivided into surgical and non-surgical groups.
		2. Korean Outpatient Group- Only cases with one of the 300 most frequent disease groups are attributed to clinics.
Lavergne M. Understanding geographic variation in health care costs in British Columbia. 201. Dissertation, University of British Columbia. Retrieved from https://circle.ubc.ca/handle/2429/52302.	This study examines variations in care through an analysis of multispecialty physician networks in British Columbia, Canada.	For this analysis, patients were assigned to the individual PCP responsible for the plurality of their primary care over the study period. This was measured by fee-adjusted dollars billed within general practice service codes, summed over the study period. In the case of a tie, the patients were assigned to the primary care provider with the most recent visit. Any remaining unlinked residents were assigned to the physician (primary care or specialist) who provided the highest total volume of ambulatory physician services. This was measured by dollars billed for visits, laboratory tests, and diagnostic tests provided in locations other than emergency departments, inpatient hospital or day surgery. Services provided in outpatient and/or ambulatory clinics located in hospitals were included. Residents who had no ambulatory contact with a physician were not linked to a usual provider of primary care, but could be linked to a network if they had hospital service use.
Roos NP. Linking Patients to Hospitals: Defining Urban Hospital Service Populations. Medical Care. 1993; 31(5): YS6–15.	This articles analyzes variations in the delivery of health services by defining urban hospital service areas.	Patients were retrospectively attributed to the physician (PCP or specialist) with whom they had the greatest number of ambulatory, out-of-hospital contacts in 1983. Patients were then linked to the hospital where they were seen most frequently by their assigned physician. If they had no hospital visits, then they were attributed to hospital based on where their physician most frequently contacted other patients. When patients could be linked to two or more hospitals, the patient was attributed to the hospital where their assigned physician practiced most often
		Other attribution approaches were also tested including: assigning patients to hospitals based on the plurality of the physicians contacted

Citation	Description	Attribution Method
Stukel T, Glazier R, Schultz S. Multispecialty physician networks in Ontario. Open Med. 2013; 7(2):e40-e55.	This study analyzes multispecialty physician networks to understand how naturally occurring relationships among physicians can be leveraged to foster accountability.	A patient was attributed to the PCP (general practitioner, family practitioner, or pediatrician) with whom he or she had been rostered at the midpoint of the study period. If a patient was not on a roster, he or she was linked to the PCP who provided the greatest amount of primary care services according to billing codes. Remaining unattributed residents were linked to any provider (PCP prioritized) who billed for the greatest number of ambulatory services. Residents without any ambulatory services were not attributed to a physician. Residents were then linked to the hospital where their physician was assigned. Unlinked patients were directly attributed to a hospital if they were admitted or visited an ED.
Provost S, Pérez J. An algorithm using administrative data to identify patient attachment to a family physician. Int J Fam Med. 2015; 2015.	The study analyzes an algorithm for attributing to patients to family practitioners using administrative data.	Attribution of patients to providers were done based on an algorithm that first considered a patient's enrollment status to the family group provider. In cases in which patients were not enrolled, patients were attributed to the provider the patient saw for a complete medical examination conducted during a two-year period. If an attribution could still not be made, patients were assigned based on concentration of visits to the same provider over time.
Analyses of Multiple Attribution Approaches		
Damberg C, Sorbero M, Hussey PS, Lovejoy S, Liu H, Mehrotra A. Exploring Episode-Based Approaches for Medicare Performance Measurement, Accountability, and Payment. Office of the Assistant Secretary of Planning and Evaluation. 2009. Retrieved from http://aspe.hhs.gov/health/reports/09/mcperform/report.pdf.	This report assesses various episode-based attribution approaches as they related to performance measurement, accountability, and payment in Medicare.	This report analyzed the following attribution approaches: 1. Episode EM visit plurality, at least 30%
		2. Episode professional payment plurality, at least 30%, single physician
		3. Episode professional payment, multiple physician, at least 25%
		4. Facility payment plurality, single facility, at least 30%
		5. Facility payment, multiple facility, at least 25%
		6. Episode professional payment plurality and facility payment plurality, at least 30% for each
Delmarva Foundation for Medical Care. Enhancing Physician Quality Performance Measurement and Reporting Through Data Aggregation: The Better Quality Information (BQI) to Improve Care for Medicare Beneficiaries Project. Delmarva Foundation for Medical Care. 2008. Retrieved from http://www.wchq.org/measures/documents/BQI_Final_Report_10_2008.pdf.	This report analyzes the validity and reliability of various attribution approaches for Medicare FFS beneficiaries using claims data.	Patients were retrospectively attributed to physicians using one of the following strategies: A) Potential for Multiple Physicians per Patient 1. One-touch rule- patient is attributed to every physician with whom he/she had at least one EM visit
		2. Two-touch rule- patient is attributed to every physician with whom he/she had at least two EM visits
		3. 30% rule- patient is attributed to every physician who submitted at least 30% of total office visits
		B) One Physician per patient: 1. 50% rule- patient is attributed to the physician who submitted at least 50% of total office visits. If two physicians each have, then the patient is randomly assigned to one physician.
		2. Maximum frequency- patient is assigned to the physician with the highest claims based on EM visits. In the case of a tie, a patient is assigned to the physician seen during the most recent visit.
Dowd B, Li C, Swenson T, Coulam R, Levy J. Medicare's Physician Quality Reporting System (PQRS): quality measurement and beneficiary attribution.Medicare & medicaid research review. 2014; 4(2).	This study evaluates the use of the PQRS reporting system to supplement existing attribution algorithms.	Patients were retrospectively attributed to providers using the following approaches: 1. Patients were attributed to the provider who accounted for the plurality of a patient's non-hospital EM visit
		2. Patients were attributed to a provider who reported a measure through the Physician Quality Reporting System
HealthPartners. Assigning Accountability to Health Care Costs: An Observational Study of Assigning Health Care Accountability. 2016. Retrieved from https://www.healthpartners.com/ucm/groups/public/@hp/@public/documents/documents/cntrb_031064.pdf	Health Partners is an integrated health care provider and insurance company based in Minnesota. This study involved the analysis of the primary care commercial claims for approximately 800,000 HealthPartners members in order to evaluate attribution approaches.	The following retrospective attribution approaches were analyzed using claims data: 1. Most Visits: All Settings – The highest percentage of primary care visits in all care settings
		2. Most Visits: Office or Outpatient – The highest percentage of primary care visits in office and outpatient settings.
		3. Most EM Visits – The highest percentage of primary care EM visits.
		3a. Most Visits: Expanded EM – The highest percentage of expanded primary care EM visits.
		4. Majority of EM Visits – Greater than 50% of primary care EM visits.
		5. Majority of Dollars: All Settings – Greater than 50% of primary care dollars.

Citation	Description	Attribution Method
Hussey P, Sorbero M, Mehrotra A. Using Episodes of Care as a Basis for Performance Measurement and Payment: Moving from Concept to Practice. Heal Aff (Project Hope). 2009; 28(5): 1406-17.	This article identifies key issues related to defining episodes and determining which provider is accountable for an episode	The following attribution approaches were evaluated: 1. The physician with the highest percentage of professional payments, over a minimum of 30%
		2. Any physician with at least 25% of professional payments
		3. The physician with the highest number of EM visits, over a minimum of 30%
		4. The facility with the highest percentage of facility payments, over a minimum of 30%
		5. All facilities with at least 25% of facility payments
		6. The facility with the highest percentage of facility payments and the physician with the highest percentage of professional payments, each over a minimum of 30%
Leapfrog Group, Bridges to Excellence. Measuring Provider Efficiency, Version 1.0. 2004. Retrieved from http://www.commonwealthfund.org/publications/other/2004/dec/measuring-provider-efficiency--version-1-0--a-collaborative-multi-stakeholder-effort.	This white paper provides an overview of best practices to improve the measurement or provider efficiency. As part of the recommendations, the pros and cons of several general attribution strategies are described.	1. Highest Cost Clinician- Of the clinician fees within each episode's total claims activity, the clinician with the highest percentage of expenses is assigned responsibility for the total episode.
		2. Clinician's Expense Percentage Threshold Episode -Responsibility is determined based on an established threshold percentage of total eligible clinician fees.
		2a. Single Clinician with Greatest Share of Professional Costs, with Threshold: responsibility is assigned to physician with the greatest share of eligible fees, but must also be greater than a threshold level
		3. PCP and Specialist Assignment For HMO and POS: episode assignment is based on either method one or two above, but the episodes would also be assigned to the member's PCP, regardless of whether the PCP had any claims activity within the episode.
		4. Virtual PCPs/Specialists: For non-gate keeper models, the assignment is made to a PCP who is involved in an episode, regardless of the percentage of clinician fees, or based on the overall historical claims history
		5. Assignment to All Involved Clinicians: For every provider involved in every episode, the provider is assigned responsibility for each episode.
		6. Major Procedure Provider: For cases where a "significant" procedure occurs within the case, the provider that renders the service is assigned responsibility for the episode, regardless of the level of involvement of other clinicians.
		7. Most Face-to-Face Encounters
Mehrotra A, Adams JL, Thomas JW, McGlynn EA. The effect of different attribution rules on individual physician cost profiles. Ann Intern Med. 2010;152(10):649–54.	This study analyzes 12 different attribution approaches for determining physician cost profiles.	In this analysis, attributions were made retrospectively, but varied on the basis of the components: a. Unit of analysis: Episode- costs are assigned separately for each condition, Patient- all costs for a patient are assigned to one or more physicians; b. Signal of responsibility: Cost- professional costs; Visits- EM visits; c. Number of physicians: Single, Multiple, d. Threshold: Majority- 50% or more, Plurality- 30% or more; Varying the components above, the researchers analyzed the following attribution approaches:1. Episode, cost, plurality
		2. Episode, cost, majority
		3. Episode, visit, plurality
		4. Episode, visit, majority
		5. Patient, cost, plurality
		6. Patient, cost, majority
		7. Patient, visit, plurality
		8. Patient, visit, majority
		9. Episode, cost, multiple-physician
		10. Episode, visit, multiple-physician
		11. Patient, cost, multiple-physician
		12. Patient, visit, multiple-physician
Pham H, O'Malley A. Primary care physicians' links to other physicians through Medicare patients: the scope of care coordination. Ann Intern Med. 2009; 150(4): 236-42.	This study analyzes the number of physicians providing primary care to Medicare patients.	Patients were attributed using the following strategies: 1. PCP that billed the greatest number of EM visits (Plurality assignment)
		2. PCP that billed for at least 50% of EM visits in the year 2005. Ties were resolved in both strategies by assignment to the physician who billed for the greatest total charges for that beneficiary.

Citation	Description	Attribution Method
Pham HH, Schrag D, O'Malley AS, Wu B, Bach PB. Care patterns in Medicare and their implications for pay for performance. N Engl J Med. 2007;356(11):1130-1139. doi:10.1056/NEJMsa063979.	Medicare Claims This study is an analysis of Medicare claims data for FFS beneficiaries that were treated by physicians who responded to the Community Tracking Physician Survey in 2000 and 2001.	Patients were retrospectively attributed to physicians using the following approaches: 1. Plurality Algorithm- Patients were assigned to the physician (or practice) with whom they had the most EM visits in a given year. To resolve ties, PCPs were prioritized followed by the physician who billed for the greatest number of charges.
		2. Plurality PCP algorithm- excludes specialists and assigns patients on the basis of primary care EM visits
		3. Majority provider algorithm- assigns patients according to the plurality of EM visits with the additional criterion that plurality must be at least 50%
		4. Multiple provider algorithm- patients were assigned to all providers who billed for at least 25% of their EM visits
Ramsey GW. Evaluating policies using agent–based simulations: investigating policies for continuity of care. International Journal of Simulation and Process Modelling. 2014; 9(4): 255-269.	This study uses agent-based simulations to evaluate different approaches to promote the continuity of care for patients with type 2 diabetes.	Patients were attributed to physicians using one of the following approaches: 1. Continuous care- each patient is randomly assigned a specific physician model for continuous care across visits
		2. Opportunistic care- each patient on each visit is opportunistically (randomly) assigned to a physician
Scholle S, Roski J, Dunn D. Availability of data for measuring physician quality performance. Am J Manag Care. 2009; 15(1):67-72.	This study evaluates how different attribution approaches influence the availability of data to assess the quality of care provided by PCPs.	The following methods to attribute patient measures to PCPs were evaluated in the study: 1. A patient was attributed to a physician if the patient had 1 or more visits during the time period
		2.Patients were retrospectively attributed to physicians that conducted at least 30% of ambulatory visits
		3. Patients were retrospectively attributed to physicians that conducted at least 50% of ambulatory visits
Scholle SH, Roski J, Dunn DL, et al. Availability of data for measuring physician quality performance. Am J Manag Care. 2009; 15(1):67–72.	This articles evaluates physician quality performance using administrative data from 9 health plans.	The following retrospective attribution approaches were analyzed: 1. A patient was attributed to a PCP if the patient had 1 or more outpatient visits during the prescribed time frame.
		2. A patient was attributed to a physician if the patient completed at least 30% of his or her ambulatory visits with that physician.
		3. A patient was attributed to a physician if the patient completed at least 50% of his or her ambulatory visits with that physician.
Sharma G, Fletcher K, Zhang D. Continuity of outpatient and inpatient care by primary care physicians for hospitalized older adults. JAMA. 2009; 301(16): 1671-80.	This article examines the continuity of care in hospitalized Medicare patients.	Patients were attributed using two approaches: 1. Beneficiaries were retrospectively attributed to the PCPs (a general practitioner, family physician, general internist, or a geriatrician) who had billed an outpatient EM code for the patient on three or more occasions in the year prior to the hospitalization.
		2. Beneficiaries were also retrospectively attributed to any physician who had billed at least one outpatient EM code in the prior year.
Thomas JW. Economic profiling of physicians: does omission of pharmacy claims bias performance measurement? Am J Manag Care. 2006;12(6):341–351.	This article evaluates the development of physician economic profiles using pharmaceutical claims.	Patients were retrospectively attributed to physicians using claims data: 1. Physicians accounted for at least 50% of the combined professional and prescribing costs
		2. Physicians accounted for at least 30% of the combined professional and prescribing costs
		3. Physicians accounted for at least 50% of professional costs
		4. Physicians accounted for at least 30% of professional costs
Thorpe C, Johnson H, Dopp A. Medication oversupply in patients with diabetes. Res Social Adm Pharm. 2015; 11(3): 382-400.	This study analyzes the supply of medications among diabetes patients managed by a large, multispecialty physician group.	The study analyzed the following approaches: 1.Plurality Provider Algorithm- Patients were prospectively attributed to the group accounting for the greatest number of EM visits in a given year;
		2. The "Diabetes Care Home" method- Patients were attributed to a provider group in a given year if they had ≥2 EM visits to a PCP or one visit to a PCP and one visit to an endocrinologist, over the current and prior year.
Wagner E, Coleman K, Reid RJ, Phillips K, Sugarman JR. Guiding Transformation: How Medical Practices can Become Patient-Centered Medical Homes: The Commonwealth Fund. 2012. Retrieved from http://www.collaboration healthcare.com/7-24-12CommonwealthMedicalPracticeto MedicalHomeFebruary2012.pdf	This reports provides guidelines on how to establish patient-centered medical homes	Patients are prospectively attributed to a PCP using the following steps: 1. Assign all patients who have only ever seen one provider to that provider. 2. Develop a list of patients with their last three to five providers seen. 3. Assign patients who have seen a provider the majority of times to the majority provider. 4. Allow clinic teams to talk through the rest of the patients and where they belong. Providers and patients then review assignments and approve links.

Citation	Description	Attribution Method
Other		
Cebul RD. Using electronic medical records to measure and improve performance. Trans Am Clin Climatol Assoc. 2008; 119:65–75.	This study analyzes the use of EMRs to measure the quality of primary care.	Patients were retrospectively attributed to a PCP according to where they received the majority of EM visits. PCPs then confirmed that the patients attributed to them were their patients.
Garnick DW, Fowles J, Lawthers AG, Weiner JP, Parente ST, Palmer RH. Focus on quality: profiling physicians' practice patterns. J Ambul Care Manage. 1994; 17(3):44–75.	This article describes the use of Medicare data to develop physician practice profiles.	Patients were retrospectively attributed to a PCP (internist, family practitioner, general practitioner) who provided the majority of care in terms of "face-to-face" visits. Total charges were used to resolve ties.
Hillman BJ, Olson GT, Griffith PE, Sunshine JH, Joseph CA, et al. Physicians' utilization and charges for outpatient diagnostic imaging in a medicare population. JAMA. 1992; 268(15):2050–54.	The article analyzes physicians' utilization of and charges of diagnostic imaging.	Patients were attributed to the nonradiologist provider who submitted a claim for the index imaging study. If no claims were submitted by nonradiologists, patients were attributed to the provider who referred the patient to a radiologist.
Hussain T, Chang H, Veenstra C, Pollack C. Fragmentation in specialist care and stage III colon cancer. Cancer. 2015; 121(18):3316-24.	This study explores whether receiving oncology care at more than one hospital is associated with cost and outcomes.	Patients were attributed to a provider in each of the following categories: 1. For surgical care, the operative surgeon was identified as the patient's surgeon, and the location of the procedure was the patient's surgical hospital. For the patients who had more than 1 colon cancer surgery, the assignment of surgical care was based on the first operation.
		2. For oncologic care, patients were assigned to the medical oncologists who billed for the plurality of their visits in the year following their diagnosis and were then designated the hospital at which these oncologists were most likely to practice. Oncologists were assigned to the hospital at which they billed for the most inpatient care. Oncologists who did not bill any inpatient claims were assigned to the hospital to which most of their patients were admitted.
Kralewski J, Dowd B, Knutson D, Tong J, Savage M. The relationships of physician practice characteristics to quality of care and costs. Health Serv. Res. 2015; 50(3):710–29.	This study analyzes the association between practice characteristics and quality	Beneficiaries were retrospectively attributed to practices if they received a plurality of their nonhospital evaluation and management (E&M) visits from a physician associated with the practice
Nyweide D, Weeks W. Relationship of primary care physicians' patient caseload with measurement of quality and cost performance. JAMA. 2009; 302(22):2444-50.	This study analyzes whether PCPs see sufficient numbers of patients to detect meaningful differences in the quality of care they provide to Medicare patients.	Patients were retrospectively attributed to all PCPs (defined as defined as internists, family practitioners, general practitioners, or geriatricians) in which they had a least one outpatient visit.
O'Malley A. Interspecialty communication supported by health information technology associated with lower hospitalization rates for ambulatory care–sensitive conditions. J Am Board Fam Med. 2015; 28(3): 404-17.	This article analyzes the association between primary care practice capabilities and hospitalizations for Medicare patients with certain chronic diseases.	Beneficiaries were retrospectively attributed to the physician who provided the plurality of their outpatient EM visits. Emergency physicians, hospitalists, surgeons, and certain medical subspecialties unlikely to serve as a patient's usual PCPs were excluded
Perloff J. Comparing the Cost of Care Provided to Medicare Beneficiaries Assigned to Primary Care Nurse Practitioners and Physicians. Health Serv Res. 2015; In Press.	This article analyzes differences in the cost of care provided to Medicare patients assigned to NPs and physicians.	Beneficiaries were retrospectively attributed to the single largest provider (pcp) of EM services in terms of cost. A 30% minimum threshold was imposed. In order to resolve ties, one pcp was randomly selected.
Perloff J, Meagher J, Bishop C, Tompkins C. Time to Readmission Among Chronically Ill Community-Resident Beneficiaries: Variations by Geographic Area and Provider Type FINAL Report. 2010. Retrieved from https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Reports/downloads/perloff_commdwellers_adverseeventschronillness_2010.pdf.	This report assesses the affect of continuity of care on the likelihood for readmissions among chronically ill patients.	Beneficiaries were retrospectively attributed to the single largest provider of EM services.
Peterson G, Xia Z, Hughes J, Wilcox L. Working Paper: Rewarding Physicians for Their Patients' Health Outcomes: What can Medicare Learn from Education's Value-Added Models. Mathematica Policy Research. 2012. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.261.3604&rep=rep1&type=pdf.	This report draws from education research to assess how approaches to reward teacher performance can be applied to value-based purchasing in health care.	Patient were retrospectively attributed only to the doctor who provided the most EM services to that patient during the year.
Romaire M, Haber S, Wensky S, McCall N. Primary care and specialty providers: an assessment of continuity of care, utilization, and expenditures. Med Care. 2014; 52(12): 1042-9.	This study analyzes health service use among Medicare patients by primary provider type (PCP or specialist).	Beneficiaries were attributed to the PCP who the beneficiary saw for the plurality of their FFS EM ambulatory visits. Attribution could be made to a PCP or certain types of specialist physicians.
Weiner JP, Parente ST, Garnick DW, Fowles J, Lawthers AG, Palmer RH. Variation in office-based quality. a claims-based profile of care provided to medicare patients with diabetes. JAMA. 1995; 273(19):1503–8.	This study conducts physician profiles for diabetes care to analyze variations in quality	Beneficiaries were retrospectively attributed to the PCP who provided more face-to-face office visits than any other provider or group. Ties were resolved by assigning patients to the PCP who provided the most intensive services (as defined by the relative value of visits and procedures).