

Working PAPER

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Population Segmentation and Targeting of Health Care Resources: Findings from a Literature Review

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ABSTRACT

Health care costs have grown steadily over the years, and a large percentage of these costs can be attributed to patients with multiple, complex health care needs. Studies note that while these “high-need, high-cost” (HNHC) patients make up to 5 percent of all patients in the nation, they account for nearly half of health care spending in a given year. Some health care organizations, particularly those taking on increased financial risk for their patients, are turning to population segmentation to help address this issue. Population segmentation seeks to efficiently targeting resources to the highest-risk, and potentially most costly, patients in health care organizations to improve quality of life and maximize efficient use of health care resources. This paper summarizes our review of the literature to identify health care delivery organizations’ approaches to segmenting their HNHC patients and using that information to tailor health care services to meet their patients’ care needs. Health care delivery organizations most commonly used a hybrid approach, combining both quantitative (for example, claims) and qualitative (for example, clinician judgment) sources of data. Resource tailoring included arranging for enhanced care management for medical, social and behavioral needs.

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I. INTRODUCTION

The government is increasingly expecting health care providers and delivery organizations to share financial risk for patients' healthcare expenditures as well as responsibility for quality and outcomes. Some of these health care delivery organizations are developing strategies to try to simultaneously lower costs in the short run and improve patient care. To this end, a number of organizations are trying to identify their high-need, high-cost patients and target outreach to them.¹ "High-need, high-cost," or HNHC, refers to patients who have complex, costly health care needs and conditions, or whose risk of developing these conditions is imminent. These individuals are a small proportion of all patients in the nation, but they account for a large percentage of health care spending. For example, 5 percent of the total population accounts for nearly half of health care spending in any given year.²

HNHC patients have heterogeneous needs. To better understand these needs, some health care delivery organizations subdivide this diverse group of patients into subgroups that have more similar health care needs. The terms "segmentation" and "stratification" are sometimes used to refer to this process.^{1,3,4,5}

Segmentation approaches are in their infancy. Some health care organizations stratify their entire population into groups that range from low to high need, and then further segment the HNHC group into subgroups on the basis of their patients' varying physical, behavioral, and social support needs.^{3,4,6} Others take different approaches to segmentation. Regardless of the process, a primary goal of segmentation is to use the results to tailor care management resources to subgroups to improve the patients' quality of life while reducing or preventing the use of costly services, such as emergency department visits and hospitalizations.⁷

Organizations use the following data sources to stratify and segment populations: (1) quantitative data, such as administrative data and claims-based algorithms,² (2) qualitative data, including clinician judgment and clinician referral; and (3) hybrid approaches that incorporate both qualitative and quantitative data.^{3,8} Authors have examined the use of either claims data or clinician judgment as the single source to refer patients for care management and have noted various limitations to their effectiveness.^{7,8,9,10} At present, hybrid approaches seem to be more reliable than using a single source of data because they incorporate multiple methods in sequence to segment a population and to identify those most likely to benefit from care management.^{3,11,12}

Most health care organizations that are taking on increased financial risk for their patients are still trying to determine the best way to segment their populations. Some, however, have more experience in developing and applying different methods of segmentation. The purpose of this report was to review the published and gray literature on how health care organizations both segment their HNHC populations into subgroups and target care management and other resources to those subgroups. In Section II of the report, we outline the research methods that guided our literature review. Next, in Section III, we describe the high-level findings from the literature review. In Section IV, we discuss the implications of our findings and identify gaps in the literature. Section V presents two tables that detail key findings from the literature.

II. METHODS

The primary purpose of the literature review was to identify methods used by health care delivery organizations to segment their HNHC population into subgroups. Segmentation approaches used by health plans or insurers is outside the focus of our study. Specifically, we wanted to identify how health care delivery organizations identify and categorize their subgroups; the data sources they use; and how, if at all, they consider patients' conditions, social needs, behavioral needs, and utilization in their segmentation efforts. A secondary aim was to understand how organizations use the segmentation results to inform how they tailored health care resources to patient subgroups.

The aims of this literature review are the following:

1. To describe how health care delivery organizations that have risk-based contracts in the United States are segmenting their populations and then further segmenting the heterogeneous high-need patients into subgroups
2. To understand how health care delivery organizations use their segmentation results to target care management and other health care resources to the high-need subgroups

Data sources and searches

We systematically searched published peer-reviewed literature and gray literature to identify approaches used to segment HNHC patients into subgroups. The gray literature included case studies or descriptions across programs that conduct subgroup segmentation. We included both quantitative and qualitative studies published between the years 2000 and 2017.

We searched the electronic databases PubMed, EMBASE, and CINHAHL. Similar search terms were used in all databases (see Table 1). Search terms were combined using “OR” and “AND” to allow for variation in themes and relevant topics.

Table 1. Search queries

Database	Keywords	MeSH [†] terms
PubMed	Super utilizer, high utilizer, high risk patients, high cost patients, high-need, complex care management, care management programs, case finding, chronic disease, risk adjustment, segment, segmentation, stratify, stratification, high need, complex patients	Risk adjustment, patient care management, chronic disease, health care cost, comorbidity, patient centered care
Scopus*	Super utilizer, high utilizer, high risk patients, high cost patients, high-need, complex care management, care management programs, case finding, chronic disease, risk adjustment, segment, segmentation, stratify, stratification, high need, complex patients	N/A
CINHAHL	Super utilizer, high utilizer, high risk patients, high cost patients, high-need, complex care management, care management programs, case finding, chronic disease, risk adjustment, segment, segmentation, stratify, stratification, high need, complex patients	N/A

*Scopus covers all EMBASE journals and citations back to 1996.

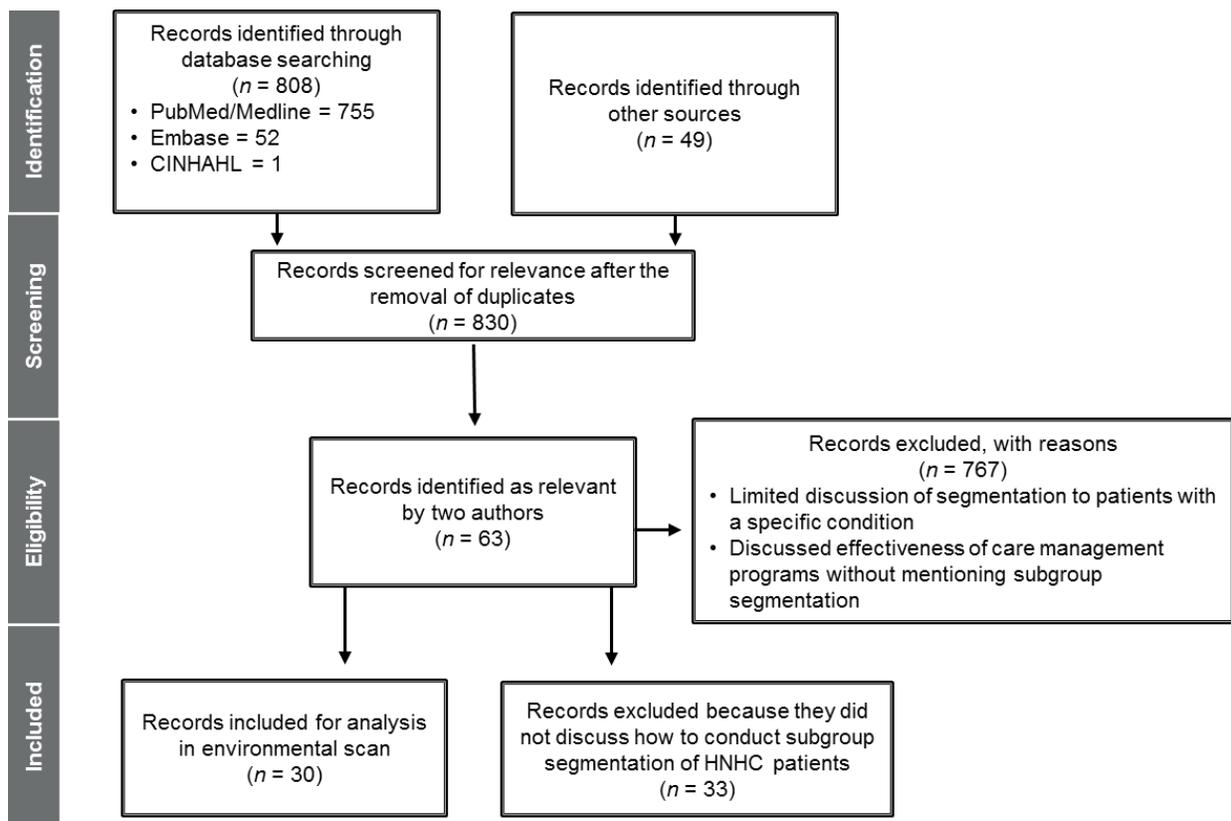
†MeSH (Medical Subject Headings) is the National Library of Medicine controlled vocabulary thesaurus used for indexing articles for PubMed.

Study selection and data extraction

A search of the databases captured 808 peer-reviewed articles, which included a search in PubMed for the names of authors who published articles that we found highly relevant to the research topic. Augmenting the search was a list of 36 potentially relevant peer-reviewed articles and gray literature provided by the Commonwealth Fund. We then used the snowball method, whereby we searched through the references cited in key articles. This approach yielded an additional 6 articles. We removed 27 duplicates in the search results. We excluded 767 articles that discussed segmentation of patients with a specific condition or that primarily discussed the effectiveness of care management programs without any description of subgroup segmentation. We also excluded articles describing programs that used only third-party vendors to segment populations. To be included, organizations had to do some of the segmentation work in-house. For example, an organization might use a proprietary algorithm from a third party (for example, Clinical Risk Groups (CRG) classification) as part of their segmentation process, but to be included in our review, they also had to do in-house analytics or use in-house clinical judgment or risk assessments to further divide their HNHC patients into clinically meaningful subgroups. We considered peer-reviewed and gray literature relevant if the authors discussed subgroup segmentation of HNHC patients.

When an article summarized several approaches from numerous different organizations, we searched the peer-reviewed and gray literature to identify whether reports from the individual programs were available. When we could not find such original articles on programs, we simply reviewed those programs on the basis of how they were summarized in the case study summary articles (for example, Hong et al. 2014¹² and Bodenheimer 2013¹³). The final analysis covers the 30 relevant articles and papers from the peer-reviewed published literature and gray literature, and excludes 33 papers that did not provide details on how to conduct subgroup segmentation (Figure 1).

Figure 1. Literature search process



While reading the articles and gray literature, we extracted key data regarding subgroup segmentation to help inform our findings. These data elements include the following:

- Programs discussed
- Target population for subgroup segmentation
- Targeted outcomes
- Segmentation process
- Names of subgroups
- Segmentation approach
- Data source(s) used to identify subgroups
- Health care (including care management) resources provided to subgroups

We then combined the data and identified themes that helped to reveal trends within the data.

III. FINDINGS FROM THE LITERATURE REVIEW

The 30 relevant articles and products outlined segmentation processes for a range of healthcare delivery organizations, including integrated delivery systems, accountable care organizations, managed care organizations, and academic medical centers. The findings also represent a range of payer types, data sources, and services targeted to HNHC patients. Tables 2 and 3 summarize key components of the relevant articles and literature reviewed. Table 2 highlights key findings, and Table 3 outlines the segmentation features of the specific programs mentioned in the literature reviewed (multiple programs may be listed for an author).

Approaches to segmentation

Segmenting HNHC patients. Health care delivery organizations most commonly used a combination of data sources to segment HNHC patients,^{5,6,7,8,13,14,15,16,17,18,19,20,22} although some used only quantitative data.^{2,6,13,23,24,25,26,27,28} The combination of quantitative and qualitative data is often referred to as a hybrid approach to segmentation.¹² Qualitative data alone were not mentioned as the source for segmentation, however, such data were always leveraged as part of a hybrid approach.

Authors noted advantages and disadvantages to using each type of data for segmentation. Quantitative administrative data such as claims are readily available and can identify patients who are currently high cost.³ Some organizations use commercially available claims-based risk-prediction modeling tools to try to predict future costs for an individual or group of people.^{29,a} A few health care organizations upload data from their electronic health records, hospitals, and emergency departments (EDs) to third-party data aggregators, which provide them more timely information on hospital and ED discharges than they could get from claims data. Using quantitative data alone for segmentation, however, fails to consider a more nuanced analysis of patient characteristics, such as willingness to participate in care management, social and behavioral issues, and clinician judgment.^{3,16,18,21} Additionally, for claims-based data, the time lag for claims processing limits the data's actionability for targeting health care service delivery.^{3,16,18,21} For all these reasons, quantitative data alone do not provide clinically actionable information on subgroups of patients and the types of care management services they need.

Qualitative data (clinician judgment, clinical electronic health record data,^b health risk assessments,^c measures of frailty, assessment of social and behavioral health needs, patient

^a Prediction tools differ from risk-adjustment in that the former tries to predict patients at risk for future high costs and high utilization, while the latter helps account for concurrent differences in health status of one population relative to another. Risk adjustment is used, for example, to adjust payment amounts to providers based on the severity of illness of the patients.

^b Most articles reviewed consider electronic health record (EHR) data as qualitative, even though electronic health records include several quantitative, standardized data elements. Although a few organizations have the capability to assess their entire population's EHR data, most lack the capability to search across all patients' EHRs for key quantitative data elements. In the future, real-time EHR data may be used in a more comprehensive way to quantitatively inform segmentation work.

^c Although some types of data from the EHR (lab values, for example) and validated health risk assessment tools are not truly qualitative, most papers lump these data sources under the general heading of "qualitative data" because

activation scores,³⁰ and so on) can help fill in the gaps not usually captured in quantitative data (claims, for example) because they capture patients' contextual factors.^{3,21} Although clinician input is important for segmenting patients into subgroups, relying on clinical judgment alone may introduce subjective bias.^{3,21} Two articles provide specific questions clinicians can ask themselves when considering whether a patient should be included in a care management program.^{13,19} These questions help identify those patients who are likely to end up in the ED or hospital without additional care management support. Most authors noted that a segmentation process that combines the strengths of quantitative and qualitative data is most reliable, actionable, and clinically meaningful.^{3,16,18,15,21,31}

Several of the articles described programs that combined quantitative and qualitative data to identify and segment their high-need, high-cost population (see Tables 2 and 3).^{3,16,21,22,27,28} Claims analyzed with predictive analytics models²⁶ to create clinical risk groups or risk scores were the most common quantitative data source.

The most commonly used qualitative data source for segmentation was clinician referral.^{13,16,17,24,26} Several articles described more intentional review of patients' clinical data by a primary care clinician or clinical team; this review was usually conducted after the programs provided the clinical team with an initial list of prospective patients (based on quantitative data analysis) to include in a care management program. A few articles described the use of patient surveys to further assess patient's functional, health, behavioral, and social risks (for example, the Vulnerable Elders Survey) and the patient's willingness to engage in future targeted care management (Patient Activation Survey).^{18, 25, 30}

Many articles noted that segmentation is an iterative process that needs to consider not only different types of data (quantitative data and clinician input) but also how patients' needs change over time.^{3,7,17,20} One of the programs reviewed, an integrated safety-net health care system, provided an in-depth overview of the iterative nature of their segmentation process. In this and other programs, regular updating with new patient data allows patients to move between segments or subgroups.⁷

Factors influencing segmentation. Segmentation programs typically consider the outcomes they want to target to guide their approach to subgroup segmentation.³ Most articles described programs that targeted a decrease in health care utilization, and thus health care spending. Strategies addressing patient utilization focused on reducing hospitalizations, emergency department visits, or readmissions and on the type of settings for post-acute care. Improving patient care was another targeted outcome that was usually mentioned in conjunction with decreasing utilization.

Payer type and associated patient characteristics also influenced segmentation processes. For example, Medicaid patients have a high prevalence of behavioral health and social support needs, in addition to their medical conditions.^{7,17,32} Patients facing social stressors or mental illness have more difficulty with self-care, and these issues also drive utilization.¹⁷ Several authors noted that a segmentation process for this population needs to pay particular attention to

they are in many cases a reflection of patient or clinician perceptions and experiences, and are not uniformly and systematically collected for all patients.

social and behavioral health needs to inform support for the patients' social, mental, and physical health care.

There was little mention in the literature about whether the type of organization (structure, ownership, governance) affected the goals of and processes for population segmentation. Similarly there was little discussion of the extent to which the health care capabilities of an organization (specific activities it can support) influenced its segmentation process.

Subgroup identification. Among the papers that clearly defined HNHC patient subgroups (see Table 3), most considered whether patients had a hospitalization and multiple ED visits in the past year. Another common theme was the presence and the severity of one or more chronic conditions.^{2,4,7,14,22,24, 26,31} A few authors described further stratification of these patients with chronic conditions into subgroups.^{2,11,14,24,31} Some also identified patients in need of transitional care (during and post-hospital discharge, for example) as a subgroup.^{7,13} Frail elders were often their own subgroup.^{2,4,5,22,31} Patients with advanced illness near the end-of-life were another commonly mentioned subgroup.^{4,5,13,18,23,24,31} Patients under age 65 with disabilities or end-stage renal disease were also mentioned as subgroups in a few articles.^{2,4,5,15} Authors of several articles noted that subgroup identification included an indicator, based on clinician judgment, of whether or not patients would be a good fit for existing care management programs.^{13,19,20,24} Additional factors that contributed to placement within a subgroup, but also spanned across subgroups, were behavioral and social needs such as lack of social support, homelessness, substance abuse

Tailoring health care to subgroups

Choosing HNHC patients for care management programs. The articles we reviewed highlighted a number of important factors to consider before choosing HNHC patients for care management. Among these are patient willingness to engage in the program, whether the patient's condition is amenable to treatment, and whether the health care delivery system has the infrastructure and capabilities to provide the care the patient needs. For some organizations with care management programs, the segmentation process is guided by data sources that can enhance the selection of patients who are more likely to respond to existing services and resources. Identifying patients' willingness to participate and engage can be challenging, but doing so can help organizations increase the cost-effectiveness of secondary preventive care.²⁶ Some of the articles described using qualitative data to identify patients' level of engagement via clinicians' face-to-face conversations with patients or using assessment tools to gauge the level of patient activation.^{13,20,24,26,30} Another approach to increasing the effectiveness of care management programs is to select patients with certain diagnosis or chronic conditions that are known to be amenable to care management.^{13,26} Some authors suggest that data sources combining quantitative data and clinician input are a better approach for identifying patients with conditions amenable to care management.²⁴ Last, some care management programs either excluded or identified alternative sources of care for patients for whom the health care delivery organization lacked the infrastructure or resources to address those patients' needs.^{13,26}

Tailoring resources. Only a few articles provided details on how segmentation results are used to tailor resources to specific HNHC subgroups.^{7,22,27} One program described resources provided to each of the four tiers it identifies, with the top two tiers receiving complex case management with enhanced care teams or treatment in an intensive outpatient clinic with linked

mental health services.⁷ Another article described resources provided to each of its five “segments” (classes) of HNHC patients in its safety-net system, with a particular focus on mental health and social needs.²⁷ The authors used individual-level administrative data representing social, behavioral, and medical conditions to develop the subgroups (segmentation) and used patient characteristics, such as housing status and type of medical condition, within each subgroup to identify potential resources or interventions.²⁷ Another article described services for each of its four subgroups of Medicare patients age 65 or older: The third subgroup receives complex case management, advanced illness coordinated care, transitional care, guided care, and geriatric consultation; and the fourth subgroup receives home-based care, social work outreach, guided care, palliative care, and hospice care.²⁶

Rather than identify the specific services tailored to each of the HNHC subgroups, most articles listed the general types of services available to patients who were deemed high risk. Most tailoring of resources concerned (1) identifying whether to enroll a patient with a nurse care manager (who typically worked as part of the primary care team)^{7,13,14,15,22,27} and/or (2) providing necessary social supports (for example, housing and food) to patients who lacked housing or food security.^{7,13,19,20,22,27} Some programs had both a primary care-based team with an embedded care manager or coordinator and cross-disciplinary teams of different types of specialists and services.^{13,14,20}

Programs commonly provided care management for chronic conditions,^{7,17,19,20, 22, 25,27} coordination with community-based services,^{7,13,19,20,22,27} such as housing and social supports, frequent in-person contact with patients,^{13,14,17,19} and linkages to mental health and substance abuse services.^{13,19,17,20} A number of programs targeting Medicaid patients offered coordination with community-based services. Care management programs serving Medicaid and Medicare patients offered frequent in-person contact, usually with a care coordinator or care manager. Although mental health and substance abuse services were present in programs targeting patients with different types of insurance, these services were a particular emphasis for Medicaid enrollees.^{7,13,17,19,20}

Patients undergoing transitions of care (from hospital to home or another facility, for example) were also targeted for enhanced care coordination.¹⁴ Those patients without a primary care physician who were identified as high utilizers of the ED and hospital were connected with a primary care clinician or with an intensive primary care clinic.^{7,17} Specific activities around coordinated care included medication management, medication reconciliation, and support to encourage patients’ compliance with recommended treatments.^{7,13,14,17,19,20} The type of organization offering care coordination services consisted mainly of clinicians and staff within integrated health care systems, managed care organizations, and programs working closely with primary care providers.^{7,13,14,22,27}

IV. DISCUSSION

Key themes

In this review, we found that the use of both quantitative and qualitative data are important in identifying clinically meaningful and actionable subgroups of HNHC patients. Predictive analytics or quantitative claims data alone are not sufficient to inform segmentation or the timely

tailoring of care to patient subgroups. Predictive-analytics risk scores aim to predict future health plan costs but often assign the same high-risk score to patients with heterogeneous clinical, social, and behavioral health needs.^{17,24,26} Thus, such scores by themselves are less helpful in identifying how to tailor health care resources to patients. The incorporation of clinical judgment, data from the electronic health record, health risk assessments, and interviews with patients require time, but including them is vital to segmentation and the tailoring of health care resources to subgroups. Segmentation and efforts to tailor health care resources also need to consider the amenability of patients' conditions to treatment and patients' willingness to engage in recommended care or care management activities.

Most articles noted that primary care clinician and team input was key to both segmentation and the tailoring of care.^{3,8,12,13,17,22,20,24,31} Primary care clinicians and primary care team members can assess patients' conditions and comorbidities, including their amenability to management, as well as patients' functional status, social support, and behavioral health needs and willingness to engage in care management. For those patients who are high utilizers but lack a primary care provider, some authors noted efforts to link them to a primary care provider or to a high-intensity clinic that focuses exclusively on high-risk patients.^{13,24,27}

Another overarching finding was the importance of using an iterative process to segment HNHC patients into subgroups, because risk factors and patients' health status change with time.^{3,7,17, 20,24} Furthermore, segmentation processes need to iterate between quantitative and qualitative data sources to ensure that they remain clinically meaningful.

Payer type (Medicare versus Medicaid versus commercial) seems to influence segmentation, as the population's needs differ by payer. For example, segmentation and care delivery models for high-cost Medicaid patients must account for a higher prevalence of undiagnosed or untreated mental illness, long-standing substance abuse conditions, and unstable housing. In the Medicare population, frailty and functional status are important issues to capture for both segmentation and tailoring of services. However, measuring these well most likely requires input from qualitative sources.^{4,18,22,24,25}

In only a few of the articles reviewed did authors note how programs specifically tailor health care resources to each of the subgroups they identified. More typically, articles listed the general types of services available to patients deemed high risk, regardless of subgroup. Future work will need to examine the extent to which organizations find it feasible to create subgroup-specific care paths and resources versus simply using segmentation results to decide whether to assign patient subgroups to intensive care management.³³

International efforts to develop classifications of HNHC patients at the population level offer some inspiration for identifying and managing meaningful subgroups of patients and creating a higher-performing health system for complex patients. These practical segmentation approaches inform policies for integrated care, population health, and strategic health planning at the regional or country level.³⁴ For example, the London Health Commission identified 15 segments based on age groups and medical, mental health, and social needs groupings.³⁵ This then led to 13 transformation programs organized around the segments that brought together multiple stakeholders with the goal of integrating care for the specific needs of people in each segment.³⁵

In Scotland, annual individual expenditures are analyzed to identify “high resource individuals”—those people who account for 50 percent of total expenditures for a given year. National Service Scotland (NSS) developed a methodology to classify highly heterogeneous group of individuals with complex care histories into a limited number of service use groupings.³⁶ This effort yields 11 segments of patient subgroups across two dimensions based on: 1) the patterns of recent service use (e.g., multiple emergency, psychiatry inpatient, residential care, extended inpatient, etc.) and 2) clinical and demographic indicators (e.g., elderly and frailty, adult major condition, mental health, low chronic conditions, etc.). This matrix provides a view of the population and can be applied at any level, from the national level down to the locality or even the population of a particular practice. The goal of this segmentation effort is to inform service redesign and identify pathways of care for those who are high cost or likely to become high cost. Although these examples relate to populations served by a coordinated national health system abroad, we could pilot test such approaches to health care delivery organizations in the U.S. that function like microsystems for similar populations.

Gaps in the literature

For the results of population segmentation to be “scalable and actionable, health systems will need more efficient ways to routinely capture social and behavioral information.”²⁷ At present, most data on social and behavioral needs is captured through individual interactions between a person on the care team (social worker, nurse, or care manager, for example) and the patient. The extent to which health care delivery organizations partnered with organizations at the community or county level to identify patients with social needs (those who are homeless or had been incarcerated, for example) is unclear. Additional research is needed to identify how health care delivery systems capture social and behavioral health information for their populations and the strategies that could make this process more efficient.

Programs described in most articles distinguished at a conceptual level between those with persistent high costs (for example, medically complex patients) and those with advanced illness who may be nearing the end of life.¹⁸ For the latter group, tailoring of health care resources tends to emphasize helping patients make informed choices about the use of hospice and palliative care services.¹⁹ We found little discussion of how and whether programs determine which patients fall into the current versus persistent high-utilizer categories. Given the inability to predict certain types of episodic use (for example, trauma), this subgroup is not the target of most segmentation efforts.

Some of the articles briefly commented on whether segmentation strategies in combination with tailored care achieved one or more of programs’ goals or intended outcomes.^{3,7,13,14,15,20,23,28} Although one article did identify an association between participation in a care management program and a reduction in Medicare spending,³⁴ a majority of the articles did not provide this information, perhaps because segmentation efforts in health care delivery organizations are still in an early stage and there has not been sufficient time to demonstrate effects. Alternatively, the lack of strong evidence to date on the cost-effectiveness of current segmentation approaches may be because efforts are targeted at too narrow a subpopulation (for example, Medicare beneficiaries with high costs) to yield a difference in costs and utilization.^{4,5}

Another challenge to assessing the effectiveness of population segmentation and resource targeting is the problem of regression to the mean, wherein a variable that is extreme at first measurement is closer to the average the second time it is measured. That is, current high utilization does not necessarily predict ongoing high utilization of health care.^{3,18,23} Only 45 percent of people in the top 10 percent of the spending tier in one year remain in the top 10 percent the following year.³⁷ Current high-cost patients include many with episodic or time-limited high use (for example, trauma or orthopedic surgery). Pre-post designs to evaluate the effectiveness of segmentation and care management programs are vulnerable to regression to the mean. We need to learn more from health care delivery organizations with a system in place to assess and evaluate the outcomes of their segmentation and care management efforts.

Additional areas for future segmentation research include the following:

- **Influence of organizational structure.** We found little discussion in the literature of how organizational structure affected segmentation goals or approach. Health care organizations vary by size, ownership type, governance, historical development (how provider groups merged or consolidated to form the health care organization), degree of clinical integration, data analysis capabilities, health care resource capabilities, and staffing capacity. Such factors may influence how a health care delivery organization approaches population segmentation and tailoring of resources.
- **Differences based on population or payer type.** Although a few of the articles described segmentation for Medicare, Medicaid, and commercially insured patients, most focused on either a Medicare or Medicaid population. As the uptake of value-based payment increases, it will be important for future research to determine how segmentation processes and subgroups differ for these populations, and payers, and where commonalities in processes may exist.
- **Influence on health care services.** Data demonstrating how segmentation results were used to tailor care were limited; in many cases, segmentation results were used simply to refer patients to a care management program.¹⁴ Future research will need to identify how segmentation results are used to specifically tailor health care resources to patient subgroups and whether that approach improved patients' quality of care and costs.

V. SUMMARY TABLES

Table 2. Summary of relevant literature

Author	Article title	Study design/ setting	Target population	Key findings
Bodenheimer ¹³	Strategies to Reduce Costs and Improve Care for High-Utilizing Medicaid Patients: Reflections on Pioneering Program	Review of 14 programs aimed at caring for high-utilizing, complex patients. Five of these programs' descriptions include how they identify their complex population (CareOregon, ^{33,38,39} Community Care of North Carolina [CCNC], ^{40,41} Hennepin County Medical Center Coordinated Care Clinic, Camden Coalition of Health Care Providers, ⁴² and Stanford Coordinated Care Program.	Medicaid enrollees who are deemed clinically complex and/or high utilizers. Of the 14 programs reviewed in this article, 5 include descriptions of how they identify their complex population: CareOregon (Medicaid managed care plan), CCNC (nonprofit community network participating in the Medicaid program), Hennepin County Medical Center Coordinated Care Clinic (academic medical center and public hospital), Camden Coalition of Health Care Providers (a group of primary care providers), and Stanford Coordinated Care Program (program for Stanford University employees and their dependents with multiple chronic health conditions).	<ul style="list-style-type: none"> • Five of the programs reviewed had reliable data and demonstrated that complex care programs for high utilizers can reduce health expenditures. • One of the programs, CCNC, followed cost and utilization measures for a number of years. The program compared enrolled high-risk patients with high-risk North Carolina Medicaid patients not enrolled in CCNC. Overall, CCNC patients had lower hospital admissions, ED visits, and total costs compared with non-CCNC patients.
Brower et al. ²³	Developing a Real-Time Predictive Model for Identifying High-Needs Patients: Atrius Health's Approach	Case study brief examining Atrius Health's patient risk assessment approach.	Ambulatory adult patients at Atrius Health (independent physicians' group) who are continuously enrolled in global risk Medicare, Medicaid, and commercial contracts.	<ul style="list-style-type: none"> • Making identification of high-risk patients clearly visible at the point of care has helped Atrius to act quickly and follow enhanced triage protocols. • In the review of a two-month time frame, Atrius Health found that hospital admission rates were lower for all high-risk groups in comparison with controls that were defined using similar clinical criteria. • Physicians have confirmed that the Clinical Risk Prediction Initiative identifies the right patients in a timely manner, which allows them to take action.

Author	Article title	Study design/ setting	Target population	Key findings
Brown et al. ¹⁴	Six Features of Medicare Coordinated Care Demonstration Programs that Cut Hospital Admissions of High-Risk Patients	Randomized controlled trial of 15 programs participating in the Medicare Coordinated Care Demonstration. Programs varied from health systems to different types of provider organizations.	<p>Eligible beneficiaries enrolled in CMS's Medicare Coordinated Care Demonstration. Eligible beneficiaries included those who</p> <ul style="list-style-type: none"> Resided in the program's catchment area Were covered by fee-for-service (FFS) Medicare, with primary Part A and Part B coverage Had one or more of the program's targeted chronic conditions Were hospitalized within a year before enrollment 	<ul style="list-style-type: none"> When developing high-risk subgroups, identifying patients with a high-risk condition is not sufficient; one may also need to include a measure of severity (e.g., a recent hospitalization) to find effects in outcome goals (e.g., lower hospitalization rates). Three out of the four demonstration programs that reduced hospitalizations among enrollees had six common characteristics. The first three characteristics featured enhanced involvement from care coordinators, who had frequent in-person contact with enrollees, met with physicians to discuss enrollees' care, and acted as the communication hub between all of the enrollee's providers. Additionally, successful programs provided evidence-based patient education, comprehensive medication management, and timely responses to transitions of care.
Haime et al. ¹⁶	Clinician Considerations When Selecting High-Risk Patients for Care Management	Qualitative interviews of primary care clinicians and nurse care managers to identify factors and patient criteria they use to identify high-risk patients for Partners HealthCare's care management program (CMP).	Medicare and commercially insured patients 18 years or older participating in the CMP at Partners HealthCare (not-for-profit health care system) in Massachusetts.	<ul style="list-style-type: none"> Hybrid approach for patient segmentation that combines claims-based analysis and clinician input incorporates many factors that are not routinely captured in clinical or billing data and minimizes the burden on clinicians by first identifying a subset of patients for review. When selecting high-risk patients to participate in the CMP, primary care physicians (PCPs) and nurse care managers consider the following factors: predisposing factors (health literacy/navigation, physical vulnerability such as frailty, and patient insight regarding his/her health), patient enabling factors (social/home environment, coping skills/health anxiety, and financial resources), and need factors (disease characteristics severity, complexity, combinations of conditions, co-occurring psychiatric disorders), and the how the interplay or combination of patient factors supported or impeded patient's ability to manage his/her own health. One additional consideration for selecting patients is whether the CMP resources would meet the needs of the patient or whether the patient was already receiving similar resources from other programs.

Author	Article title	Study design/ setting	Target population	Key findings
Hasselman ¹⁷	Super-Utilizer Summit: Common Themes from Innovative Complex Care Management Programs	Center for Health Care Strategies brief highlighting key findings from a Super-Utilizer Summit. Attendees included national and state governments, nonprofit organizations, and various other types of health care stakeholders.	HNHC Medicaid patients participating in complex care programs.	<ul style="list-style-type: none"> When stratifying subgroups, programs participating in the summit noted that they include a readiness-to-change factor at an individual patient level because they believe CMPs are more effective when a patient is willing to make changes. Programs stressed that using data to segment subgroups is an iterative process because risk factors are dynamic and are likely to change.
Health Care Transformation Task Force ¹⁸	Proactively Identifying the High Cost Population	White paper that highlights key learnings from experienced and successful programs aimed at transforming care for high-cost patients.	High-cost, complex patients.	<ul style="list-style-type: none"> When identifying patients who are persistently high cost, the authors note that it's important to distinguish between common diagnoses and common diagnoses that drive spending. Claims-based algorithms can be helpful in identifying high-cost patients, but they do have several limitations, such as not incorporating data that are good metrics of disease progression and functional status.
Health Care Transformation Task Force ¹⁹	Developing Care Management Programs to Serve High-Need, High-Cost Populations	White paper outlining how to develop CMPs in the context of value-based payment initiatives. The paper also includes case studies with clinically and financially successful programs, including a purchaser-led program at the Pacific Business Group on Health's Intensive Outpatient Care Programs (IOCP) ³³ and the Montefiore Health System.	<p>IOCP: HNHC Medicare patients within 23 delivery systems in five states (Arizona, California, Idaho, Nevada, and Washington) participating in Pacific Business Group's Intensive Outpatient Care Programs.</p> <p>Montefiore: High-risk patients who are often overlooked because they do not seek out care.</p>	<ul style="list-style-type: none"> The IOCP collected patient data throughout the program and found the following patient-centered outcomes: <ul style="list-style-type: none"> Increased patient activation—37 percent of IOCP patients moved to a higher level of activation while in the program Decreased depression risk: Patient Health Questionnaire (PHQ) scores improved by 31 percent. The PHQ is a tool to screen, diagnose, monitor, and measure depression. For complex patients who are commercially insured, Montefiore was able to reduce the diabetes admission rate for one commercial insurer from 343 per 1,000 in 2009 to 299 per 1,000 in 2014.

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Hong ³	Finding a Match: How Successful Complex Care Programs Identify Patients	Report on CCMs. Five of the programs highlighted in the brief provided details about their segmentation process (Cambridge Health Alliance, Iora Health, Denver Health, Geisinger ProvenHealth Navigator, ^{33,43} and Geriatric Resources for Assessment and Care of Elders [GRACE] ^{33,44}).	High-risk patients at various health care organizations with complex care programs.	<ul style="list-style-type: none"> • The majority of programs reviewed use the hybrid approach to select patients for complex care programs. These programs most often use a quantitative approach to generate a list of high-risk patients, and then the PCP or care team provide a clinical review or assessment. • A clinical review incorporates a PCP's depth of knowledge about the patient and introduces consideration of psychosocial factors, the presence of a caregiver, or whether an active care team is already in place. • Most interviewees noted that choosing the right patients who will adhere to the care provided in CCMs requires a qualitative approach. • "Successful CCM programs align the selected subgroup, intervention and outcomes of interest by performing three tasks: <ol style="list-style-type: none"> 1. Specify, priority and agree on the outcomes of interest and time frame for achieving them 2. Identify a sufficiently high-risk and care-sensitive target population in which the outcomes can be achieved. 3. Match the planned staffing and resources and interventions to the target population to achieve the desired outcomes, building on existing services to fill care gaps." (Hong 2015)
Horn et al. ²⁰	The Economic Impact of Intensive Care Management for High-Cost Medically Complex Patients: An Evaluation of New Mexico's Care One Program	Quasi-experiment using historical cohort data at The University of New Mexico (UNM) Health Sciences Center (HSC).	High-cost (top 1 percent), medically complex patients at UNM's HSC (public teaching hospital).	<ul style="list-style-type: none"> • The authors noted that the assessment process used by primary care providers to evaluate patients prior to selection into the Care One program is a critical component that allows the care team to identify social factors impacting the care of patients. • The authors conducted a difference-in-difference analysis utilizing a control group, and estimated a per-patient reduction in billing charges of \$44,504.
Hostetter and Klein ⁶	In Focus: Segmenting Populations to Tailor Services, Improve Care	Issue brief examining health care delivery organizations that are sources of data other than claims to gain a more complete picture of patients' needs. One of	High-risk patients who may be at high risk for health problems and need additional help within Bellin Health.	<ul style="list-style-type: none"> • In combination with electronic health record data, Bellin Health uses various other data sources, such as where a patient lives, insurance status, and whether their medical bills have been sent to a collection agency to flag potential problems their patients are facing.

Author	Article title	Study design/ setting	Target population	Key findings
		the organizations is Bellin Health (integrated delivery system).		
Hsu et al. ³⁴	Bending the Spending Curve by Altering Care Delivery Patterns: The Role of Care Management within a Pioneer ACO	Analysis conducted at Partners Healthcare Pioneer ACO (Refer to Vogeli et al. ²¹ for additional details about Partners ACO).	Medicare patients who were initially aligned with Partners ACO in 2012 or 2013, and identified in any year between 2012 and 2014 by their PCP as having potentially modifiable elevated risks for future spending, and chose to participate in the CMP.	<ul style="list-style-type: none"> • Participation in the CMP was associated with a reduction in Medicare spending of \$101 per participant per month, a decline of 6 percent. The spending reductions increased with longer program exposure, in a stepwise fashion. • Targeting beneficiaries with high risks that their PCPs believe are modifiable appears to be a viable strategy, as opposed to more diffuse strategies that target broader ACO populations.
Institute for Healthcare Improvement (IHI) ³¹	Care Redesign Guide	IHI developed the guide using their experience working with over 200 organizations in the Triple Aim Improvement Community and the Better Health and Lower Costs for Patients with Complex Needs Collaborative.	Patients with complex needs and high health care costs.	<ul style="list-style-type: none"> • Choosing a population segment of individuals with complex needs and high costs, and learning about their needs, is strategically important during the early stages of developing the enhanced care model as well as for its long-term sustainability. • The authors suggest meeting with primary care clinicians to review the list of patients in the population segment and asking them to consider the following questions when determining who will be included in the enhanced care model: <ul style="list-style-type: none"> ○ Who is on a steady health decline trajectory? ○ Who, without more intensive assistance now, is going end up in the emergency room or the hospital? ○ Who keeps you up at night? ○ For whom do you need some extra intelligence (eyes and ears) in the home?
Johnson et al. ⁷	For Many Patients Who Use Large Amounts of Health Care Services, the Need Is Intense Yet Temporary	Cross-sectional and longitudinal analysis conducted at Denver Health (DH).	Patients of all insurance types receiving care at DH (integrated safety-net health care system) from May 2011–April 2013.	<ul style="list-style-type: none"> • The financial, clinical and demographic characteristics of the super-utilizer population remained steady across the study period. • Individual super-utilizers cycled in and out of super-utilizer status on a monthly basis. • Targeted interventions at the individual level should take into consideration the differences between individuals with consistent high utilization versus those with time-limited episodes of super-utilization. • Super-utilizers had more than one comorbid chronic condition, including mental health conditions.

Author	Article title	Study design/ setting	Target population	Key findings
Johnson et al. ¹¹	Augmenting Predictive Modeling Tools with Clinical Insights for Care Coordination Program Design and Implementation	Case study of DH's 21st Century Care project.	Publicly insured and uninsured patients who receive or could benefit from primary care at a DH primary care clinic.	<ul style="list-style-type: none"> • Risk-stratification cannot rely solely on predictive modeling and risk adjustment tools because they do not distinguish between necessary and potentially avoidable utilization. • Segmentation approaches that combine clinical input with predictive modeling or risk adjuster tools can better identify high-risk patients amenable to primary care team interventions.
Joynt et al. ²	Segmenting High-Cost Medicare Patients into Potentially Actionable Cohorts	Medicare claims analysis using claims from 2011 (baseline year, used to determine comorbidities and subgroups) and 2012 (spending year).	High-cost patients in Medicare FFS population.	<ul style="list-style-type: none"> • Among the subgroups, frail elders were the highest cost subgroup. Patients with a disability or end-stage renal disease were the next highest cost group.
Kelley et al. ²⁵	Identifying Older Adults with Serious Illness: A Critical Step toward Improving the Value of Health Care	Retrospective analysis of patients 50 years and older participating in the longitudinal Health and Retirement Study (HRS) cohort.	Medicare patients participating in the HRS cohort who had continuous Medicare Parts A and B FFS coverage from 2002 to 2010.	<ul style="list-style-type: none"> • The authors demonstrated that older patients with a high risk of hospitalization and high Medicare costs and mortality can be prospectively identified using the three subgroups identified in the article. • Considering functional limitations, in addition to the presence of a serious condition, is critical to identifying seriously ill patients who are at risk for negative outcomes. • The majority of seriously ill older adults with evidence of high cost and utilization were not in the last year of life. • The segments captured patients with continuously high utilization, and the data showed high costs in the years that followed the study period.
Lewis ²⁶	Impactability Models: Identifying the Subgroup of High-Risk Patients Most Amenable to Hospital-Avoidance Programs	Semi-structured interviews with representatives from 30 organizations that build, use, or appraise health care predictive models. Primarily focuses on disease management programs.	High-need, high-cost patients.	<ul style="list-style-type: none"> • The author notes that one way to improve the effectiveness of programs aimed at preventing hospitalizations is to target upstream care to high-risk patients whose risk can be mitigated, which can be done by using an impactability model. • Interview respondents described three types of impactability models that may refine the output of predictive models: (1) give priority to patients with diseases that are particularly amenable to “preventive care”—a term the author uses to refer to secondary prevention of chronic conditions; (2) exclude patients who are least likely to respond to such care; or (3) identify the form of preventive care best matched to each patient’s characteristics. The author notes that

Author	Article title	Study design/ setting	Target population	Key findings
				<p>some exclusions (e.g., disease management programs that exclude persons with serious mental illness) risk impeding access to care for vulnerable populations.</p>
<p>Long et al.³³</p>	<p>Effective Care for High-Need Patients: Opportunities for Improving Outcomes, Value, and Health</p>	<p>Assessment on strategies for better serving high-need patients.</p>	<p>High-need patients</p>	<ul style="list-style-type: none"> • The authors note that while the high-need patient population is diverse, a synthesis of analyses in the literature identified three criteria that could form a basis for defining and identifying the high need population: total accrued health care costs, intensity of care utilized for a given period of time, and functional limitations. • Since high-need patients' needs extend beyond care for their physical ailments to social and behavioral services, addressing clinical needs alone will not improve outcomes or reduce costs for this population. • Care models that have been shown to be successful share a number of common attributes, which can be organized in an analytic framework with the following four dimensions: focus on service setting, care attributes, delivery features, and organizational culture.
<p>Lynn et al.⁴ and review of Bridges to Health (Outcomes Based Healthcare⁵)</p>	<p>Using Population Segmentation to Provide Better Health Care for All: The "Bridges to Health" Model Segmentation for Outcomes: Using the Bridges to Health Model for Outcomes Based Commissioning</p>	<p>Lynn: Concept paper outlining the segmentation of the whole population into specific segments. Outcomes Based Healthcare: Report of the Bridges to Health model and its application to outcomes measurement.</p>	<p>Whole population, but additional description of how to divide complex patients into smaller subgroups.</p>	<ul style="list-style-type: none"> • Although both articles segment the whole population, the Stockport Together program (Outcomes Based Healthcare 2016) provides additional details on specific segments (Segments 4–8) that include HNHC patients. • There is considerable overlap and movement of HNHC patients between Segments 4 and 8. Patient movement between segments may be the result of disease progression or the development of a disability. Also, as a patient's disease progresses, concurrent trajectories result in overlap between segments.
<p>Rinehart et al.²⁷</p>	<p>Identifying Subgroups of Adult Superutilizers in an Urban Safety-Net System Using Latent Class Analysis</p>	<p>Retrospective cohort analysis conducted at DH, an integrated safety-net health care system in Denver, Colorado.</p>	<p>Adult patients who had an admission at DH in 2014 and two or more admissions within the preceding 12 months.</p>	<ul style="list-style-type: none"> • The results of the latent class analysis demonstrated that a combination of social, behavioral, and medical data can help health care systems understand the connection between medical needs and the social determinants of health that impact patients in the high-risk subgroups.

Author	Article title	Study design/ setting	Target population	Key findings
Vogeli et al. ²¹	Implementing a Hybrid Approach to Select Patients for Care Management: Variations Across Practices	Retrospective cohort analysis conducted at Partners Healthcare Pioneer ACO. (Refer to Hsu et al. ³⁴ for additional details about Partners ACO.)	Medicare patients in the Partners Healthcare Pioneer ACO in 2013, in Massachusetts.	<ul style="list-style-type: none"> • The characteristics associated with being considered high-risk for poor outcomes are advanced age, higher prospective risk score, a recent increase in diagnosed conditions, higher number of medical hospitalizations or days in a skilled nursing facility, and more visits to a PCP but a shorter relationship with a provider. • Primary care teams use additional, nonclinical information (e.g., experience with patient) both to assess whether a patient is high risk and to select patients for CMPs. • There was variation in the overall risk-adjusted proportions of patients identified as high risk across the primary care practices, which suggest that PCPs are not using the same criteria to identify high-risk patients.
Vuik et al. ²⁸	Patient Segmentation Analysis Offers Significant Benefits for Integrated Care and Support	Description of examples of international patient segmentation cases.	Patients receiving care in the Valencia region of Spain. Of the three programs reviewed, the ValCronic program used segmentation to identify subgroups.	<ul style="list-style-type: none"> • The ValCronic program in Spain, which followed 200 patients for one year and provided telemonitoring and patient education services, showed a 51 percent reduction in the use of emergency primary care services and a 32 percent reduction in the use of emergency acute care. • Patients reported high satisfaction with the services provided, and 86 percent said that it helped them better understand their disease.
Zhou et al. ²²	Improving Care for Older Adults: A Model to Segment the Senior Population	Multiple validation methods to test the Senior Segmentation Algorithm at Kaiser Permanente.	Medicare patients 65 years or older who receive care from Kaiser Permanente (integrated managed care organization).	<ul style="list-style-type: none"> • The senior algorithm assignments reached 85 percent concordance with physician assignments of patients into care groups.

Table 3. Key segmentation factors

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
Bodenheimer ¹³	Medicaid enrollees who are deemed clinically complex and/or high utilizers and are served by CareOregon, ^{33,38,39} a Medicaid managed care plan	Decrease utilization and spending of complex patients.	<ol style="list-style-type: none"> 1. Create list of high utilizers using patient data. 2. Clinicians review list and help predict costly patients using four queries: <ul style="list-style-type: none"> o Who is on a steady health decline trajectory? o Who, without more intensive assistance now, is going to end up in the ED or the hospital? o Who keeps you up at night? o For whom do you need some extra intelligence—eyes and ears in the home? 3. Clinicians select patients for program. 	<ol style="list-style-type: none"> 1. No inpatient stay/six or more ER visits 2. One non-OB inpatient and zero to five ED visits 3. More than two non-OB inpatient or one non-OB inpatient and six or more ER visits 	Hybrid: <ul style="list-style-type: none"> • Quantitative = claims, clinical data, predictive modeling, and GIS mapping • Qualitative = clinical review and input 	CareOregon patients are added to one of the following models: <ul style="list-style-type: none"> • CareSupport model: Care management team aligns with primary care practices to provide patient support by telephone • Health Resilience Program model: Expands clinical teams by adding a Health Resilience Specialist to work face-to-face with patients in the community
Bodenheimer ¹³	Complex Medicaid patients participating in Community Care of North Carolina (CCNC), ^{40,41} a nonprofit community network	Decrease utilization and spending of complex patients.	<ol style="list-style-type: none"> 1. Conduct “impact segmentation,” whereby every patient is assigned to a clinical risk group. 2. Within each risk group, every patient is assigned an impactability score of 0 to 1,000. Score reflects likely cost savings per patient per month over the next six month for patients who receive care management. 	CCNC appears to have revised how they create subgroups between 2013 and 2015 to emphasize impactability scores. They identified the following segments: <ol style="list-style-type: none"> 1. Patients with the highest impactability scores 2. Patients with the highest risk of inpatient admission 	Quantitative = claims data (above-expected potentially preventable hospital costs, utilization patterns, clinical characteristics)	<ul style="list-style-type: none"> • Individualized care plans • Care manager coordinates care across various settings and ensures care plan is implemented • Care managers have face-to-face meetings with patients

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
			<p>Prioritize patients with a Complex Care Management impactability score above 200.</p>	<p>3. Patients with high risk but low impactability</p>		<ul style="list-style-type: none"> • Medication reconciliation and education • Education to patients and their families (red flags for patients' condition, when to call PCP, how to avoid hospitalization)
<p>Bodenheimer¹³</p>	<p>Complex patients at Hennepin County Medical Center's Coordinated Care Clinic, with three or more hospital admissions in past year</p>	<p>Decrease utilization and spending for complex patients.</p>	<p>Ask patients with three or more hospital admissions in the past year to join their program.</p>	<ol style="list-style-type: none"> 1. High-utilizing patients who sign up for Hennepin's care coordinated care clinic program 2. High-utilizing patients who do not sign up for Hennepin's care coordinated care clinic program 	<p>Quantitative = Hospital utilization data</p>	<ul style="list-style-type: none"> • Transportation (taxi vouchers or bus passes) • Medical, behavioral, and social assessment • Home visits • Collaboration with shelter-based care teams • Social worker or registered nurse support
<p>Bodenheimer¹³</p>	<p>High-risk patients who are treated by the Camden Coalition of Healthcare Providers,⁴² which is a primary care-based CMP</p>	<p>Decrease utilization and spending for complex patients.</p>	<p>Identify patients with two or more inpatient admissions in the last six months, patients with two or more chronic disease-related admissions, and patients with polypharmacy.</p>	<ol style="list-style-type: none"> 1. One-time ED/low average cost population 2. Low inpatient/medium ED utilizing/medium-cost population 3. High ED utilizing/high-cost population 4. High inpatient utilization/high-cost population 	<p>Quantitative = Hospital utilization data</p>	<ul style="list-style-type: none"> • Home visits • Outreach to homeless patients on the streets • Assist in accessing primary care • Medication reconciliation and adherence support • Transportation support

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
				Exclusion criteria: Patients with a pregnancy-related admission, oncology-related admission, psychiatric primary diagnosis without chronic disease, postsurgical acute condition, and diagnosis of a progressive disease for which there is no treatment.		<ul style="list-style-type: none"> • Coordinated care • Social support • Health coach or community health worker support
Bodenheimer ¹³	Complex patients participating in Stanford's Coordinated Care Program, which is a program for Stanford University employees and their dependents with multiple chronic health conditions	Decrease utilization and spending for complex patients.	<ol style="list-style-type: none"> 1. Select patients for program through <ol style="list-style-type: none"> a. Physician or practice manager referral b. Self-referral c. Millman predictive model identifying high-utilizing patients d. Identifying patients with five or more chronic medications, three or more specialists, two ED visits a year or one hospital admission in a year 2. Administer intake assessment 	<ol style="list-style-type: none"> 1. Patients are put into four Patient Activation Measure (PAM) categories (1 is unengaged and 4 is totally engaged) 2. Patients are then put into four domains: <ol style="list-style-type: none"> a. Social isolation b. Care access/coordination/trust issues c. Medical trajectory/complexity d. Behavioral issues/self-management support. 	Hybrid: <ul style="list-style-type: none"> • Quantitative = claims data • Qualitative = physician and practice manager referral, self-referral 	<ul style="list-style-type: none"> • Care plan based on PAM/domain assessment • Face-to-face meetings between care coordinators and patients before physician visits • Home visits • Care coordinators attend physician visits • End-of-life care counseling • Pharmacy support for asthma and diabetes • Post discharge coordinated care
Brower et al. ²³	Ambulatory adult patients at Atrius Health (independent physicians' group) who are continuously enrolled in global	Create a tool that determines patients' risk levels and makes them easily visible to providers so that they can	Atrius developed a predictive modeling tool, the Clinical Risk Prediction Initiative. The tool takes the following steps to segment the high-risk population:	<ol style="list-style-type: none"> 1. Advanced illness 2. High risk 3. Complex rising risk 4. Risk prevention 	Quantitative = Data from Atrius Health's enterprise data warehouse, including clinical data from the Epic EHR; admissions, discharges, and	Author did not indicate what resources Atrius Health provides to high-risk patients.

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
	risk Medicare, Medicaid, and commercial contracts	deliver needed care	1. Pulls EHR and claims data, in addition to patient hospital admission feeds 2. Uses 138 variables across medical and pharmacy utilization, diagnoses, and sociodemographic factors to predict a patient's risk of hospitalization within six months (low risk: < 20 percent; moderate risk: 20–50 percent; and high risk: > 50 percent) 3. Segments high-risk patients into four subgroups		transfers feeds; and payer claims	
Brown et al. ¹⁴	Eligible beneficiaries enrolled in CMS's Medicare Coordinated Care Demonstration	Decrease hospitalizations and Medicare Part A and B spending per month	The authors conducted exploratory tests for four alternative and overlapping subgroups at high risk of subsequent hospitalization.	High-risk enrollees were segmented by types of conditions and number of hospitalizations: 1. Congestive heart failure (CHF) 2. CHF, chronic obstructive pulmonary disease (COPD), or coronary artery disease 3. More than one of the conditions listed above and one or more hospitalizations in the first year before enrollment 4. Diabetes, stroke, cancer, depression, dementia, atrial fibrillation, osteoporosis, rheumatoid arthritis or osteoarthritis, or chronic kidney disease, in addition to more than	Quantitative = Medicare claims on hospital admissions, Part A and B expenditures, care management fees, and data from Medicaid enrollment database (2002–2008)	Segmentation was completed for purposes of the study. The authors did note the following characteristics of the Medicare demonstration programs that achieved a reduction in hospitalizations: <ul style="list-style-type: none"> • Frequent in-person contact with enrollees • Care coordinators met with physicians to discuss enrollees' care • Care coordinators acted as the communication hub between all the enrollee's providers

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
				<p>two hospitalizations in the two years prior to enrollment</p> <p>Exclusion criteria: Each program excluded some beneficiaries on the basis of having certain conditions, such as terminal illness or severe cognitive impairments.</p>		<ul style="list-style-type: none"> • Provided evidence-based patient education • Included comprehensive medication management • Incorporated mechanisms to inform care coordinators when an enrollee was hospitalized.
Haime et al. ¹⁶	Medicare and commercially insured patients 18 years or older participating in a primary care based, nurse-led CMP at Partners HealthCare (not-for-profit health care system).	Assist high-risk patients to better manage their health and healthcare utilization.	<ol style="list-style-type: none"> 1. Upload prior year of paid claims to Optum ImpactPro software and generate chronic conditions, utilization patterns and a predictive risk score for future total medical expense. 2. Use an internally developed algorithm that incorporates an overall risk score, combinations of specific chronic conditions, and patterns of health care utilization to develop an initial list of the 5 percent of patients identified as high-risk. 3. Sort patients into a PCP-specific list for clinical review. 4. PCP and nurse care manager dyad review list and select patients appropriate for CMP. 	<ol style="list-style-type: none"> 1. Appropriate for the CMP 2. Not appropriate for the CMP <p>Exclusion criteria: Some interviewees excluded patients whose primary diagnosis was a psychiatric or substance abuse condition because they felt the CMP did not yet have the resources to meet these patients' needs.</p>	<p>Hybrid:</p> <ul style="list-style-type: none"> • Quantitative = billing claims • Qualitative = PCP and nurse care manager review of patients' needs based on knowledge of patients and their medical, social, and behavioral issues. 	The CMP involved primary care-based care management by a PCP and nurse care manager. (Description of CMP was not the focus of this article.)

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
Hasselman ¹⁷	HNHC Medicaid patients participating in complex care programs. Of the programs discussed, only one program, Washington State Department of Social and Health Services, provided details for conducting segmentation.	Decrease medical cost for Medicaid patients.	<p>Brief provided a high-level description of common steps involved in the program's segmentation process:</p> <ol style="list-style-type: none"> 1. Use predictive modeling to examine 15 months of integrated health care claims to estimate future medical costs and inpatient risk scores 2. Stratify patients into subgroups by identifying patients with extreme ED utilization, high expected future medical costs, high prospective inpatient risk scores, and significant gaps in care and quality indicators 	<p>Author did not note specific subgroups used by super-utilizer programs.</p> <p>Exclusion criteria: Examples of exclusion criteria used by this program include</p> <ul style="list-style-type: none"> • Inpatient admissions related to pregnancy, oncology, trauma, or a surgical procedure for an acute condition • Advanced age (e.g., more than 80 years of age) and a dementia diagnosis • Someone declining to participate in the super-utilizer program 	<p>Hybrid:</p> <ul style="list-style-type: none"> • Quantitative = claims, electronic health records, patient demographic files, and real-time notification of inpatient admissions • Qualitative = information from conversations with patients/caregivers and care teams 	<p>Examples of common interventions offered by super-utilizer programs:</p> <ul style="list-style-type: none"> • Extensive outreach and engagement strategies • 24-hour on-call system • Frequent contacts with patients, with priority placed on face-to-face contact • Comprehensive medication reconciliation and management • Patient-caregiver self-management education • Timely outpatient follow-up post discharge • Linkage to a primary care provider/medical home • Health education and health coaching • Pain management • Management of chronic conditions (e.g., diabetes) • Linkages to housing, substance abuse treatment, and other community resources

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
Health Care Transformation Task Force ¹⁸	High-cost, complex patients	Improve care and reduce cost for high-cost patient populations.	The workgroup provides a recommendation from a recent report, which concluded that a hybrid method is the most reliable approach to identify high-cost patients. Examples of data used for hybrid approach are listed under data source.	<ol style="list-style-type: none"> 1. Patients with advanced illness 2. Patients with persistent high spending patterns 3. Patients with episodic high spending (The workgroup notes that this group of patients cannot be targeted proactively because the high-cost medical events are seldom foreseeable or predictable) 	Hybrid: <ul style="list-style-type: none"> • Quantitative = claims-based algorithm that includes a utilization criterion, number of chronic conditions, absence of PCP visits • Qualitative for Subgroup 1: Physician report, patient self-reported state of health, Vulnerable Elders Survey, indications of active functional or nutritional decline. For Subgroup 2, patient health questionnaire, depression, PAM, physician referral, homelessness 	Authors did not describe tailoring resources to the high-cost patients within the context of proactively identifying patients. They have a separate white paper that provides case studies of CMPs more generally (Health Care Transformation Task Force ¹⁹).
Health Care Transformation Task Force ¹⁹	HNHC Medicare patients within 23 delivery systems in five states (Arizona, California, Idaho, Nevada, and Washington) participating in Pacific Business Group on Health (PBGH) Intensive Outpatient Care	Drive health care improvements by closely linking a multidisciplinary team to primary care to address the needs of HNHC patients	<ol style="list-style-type: none"> 1. The IOCP recommended that delivery systems use a combination of predictive risk scoring with clinical judgment to identify HNHC patients 2. If health systems did not have access to predictive software, IOCP recommended a utilization based algorithm: 	<ol style="list-style-type: none"> 1. HNHC patient selected for CMP. 2. HNHC patients not selected for CMP. 	Hybrid = IOCP recommends a combination of predictive risk scoring and clinical judgment.	Patients receive the following services while participating in the care management program: <ul style="list-style-type: none"> • Face-to-face supervisit • Longitudinal assessment • Monthly, bidirectional communication with care coordinator

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
	<p>Programs (IOCP).³³ PBGH is a health purchasing organization for member companies.</p>		<p>a. Two or more admissions, in last year, with one in last six months</p> <p>b. Six or more ED visits in last year</p> <p>3. Best practices included sharing the algorithm-based patient list with the PCP and asking which patients from the list they would recommend for intensive care management</p>			<ul style="list-style-type: none"> • Shared action plan • 24/7 access
<p>Health Care Transformation Task Force^{6,19}</p>	<p>High-risk patients at Montefiore Health System (academic medical center) who are often overlooked because they do not seek out care.</p>	<p>Deliver care management service to patients with complex illnesses and coordinate care across acute and post-acute care settings.</p>	<p>The care management organization identifies HNHC patients within the managed population through data mining, self-referral, and provider referral.</p>	<p>Author did not note whether Montefiore created specific subgroups.</p>	<p>Hybrid = Authors did not identify the specific data used during data mining for identification of HNHC patients.</p>	<p>An accountable care manager administers a biopsychosocial assessment to identify specific interventions and resources for the patient, which include:</p> <ul style="list-style-type: none"> • Chronic care management programs for diabetes, heart failure, asthma/COPD • Telemonitoring • Medication reconciliation, adherence, and optimization • Linkage to community support services and entitlement programs • Behavioral health management

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
						<ul style="list-style-type: none"> • Life care planning and advanced illness management • Inpatient care monitoring • Caregiver support
Hong ^{3,†}	Patients at Cambridge Health Alliance (safety-net delivery system)	Identify care sensitive, high-risk patients to include in complex care programs.	<ol style="list-style-type: none"> 1. The Cambridge Health Alliance identifies high-risk patients using three claims-based risk predictors for different payer populations. 2. Select high-risk patients in monthly batches and present them to care teams for qualitative clinical assessments. 3. Along with individualized patient summaries, the primary care team reviews the lists of patients. The questions the team considers are: <ol style="list-style-type: none"> a. Would you be surprised if this patient was admitted to the hospital in the next six months? b. Would the patient engage in care management? c. Does the patient have an unmet medical need or care gap that the CCM team could help with? d. Where should the patient be referred for additional support (e.g. CCM 	<ol style="list-style-type: none"> 1. Selected for CCM program. 2. Not selected for CCM program. 	Hybrid: <ul style="list-style-type: none"> • Quantitative = health expenditures, clinical data on acute utilization • Qualitative = primary care team assessment 	Authors did not describe specific resources provided to high-risk patients.

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
			<p>program or other CMPs)?</p> <p>4. Combine data from assessment with clinical data on acute care utilization.</p> <p>5. A triage scoring system uses the combination of data to select patients for the CCM program.</p>			
Hong ³	Patients at Iora Health (primary care delivery organization)	Identify care sensitive, high-risk patients to include in complex care programs.	<p>1. Risk-stratify patients using the Milliman Adjusted Risk Score, focusing on the top decile of risk for future cost.</p> <p>2. Pair the risk-stratification results with an internally developed risked assessment called the "Worry Score." The score takes into account diagnoses and control of chronic conditions, recent acute care utilization, and a list of modifiers including smoking status, age, and socioeconomic risk factors.</p> <p>3. Select patients with a certain score into their complex care management CCM program.</p>	<p>1. Selected for CCM program.</p> <p>2. Not selected for CCM program.</p> <p>Exclusion criteria: Examples of criteria used by programs include the following:</p> <ul style="list-style-type: none"> • Patients who are not sufficiently high-risk, including those who have a time-limited, high-cost episode that has resolved, such as a trauma event or a high-risk pregnancy • Patients who have their care needs met, such as those with a strong network of family caregivers or those with a comprehensive care team 	<p>Hybrid:</p> <ul style="list-style-type: none"> • Quantitative = data from claims, EMRs, data warehouses, and surveys • Qualitative = primary care team risk assessment 	Authors did not describe specific resources to provide to high-risk patients.
Hong ³	Medicare and commercial insurance patients at Geisinger	Identify care sensitive, high-risk patients to include in	Geisinger identifies patients who meet the following criteria as eligible for the care management program: ³	1. Selected for CCM program.	<p>Hybrid:</p> <ul style="list-style-type: none"> • Quantitative = claims, internal data warehouse, 	Authors did not describe specific resources to provide to high-risk patients.

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
	Health ³³ (integrated delivery system)	complex care programs.	<ol style="list-style-type: none"> 1. Risk predictor: MEDai (highest-risk groups and patients moving up two or more risk groups), predicted risk 2. Utilization: three or more ED visits or more than one admission in six months 3. Cost: More than \$50K spent per year 4. Diagnoses: heart failure, COPD, and end-stage kidney disease (Medicare) 5. All hospital discharges for Medicare patients or those meeting the following criteria: 55 years or older, hospital length of stay or five or more days, diagnoses of high-risk cancer, heart failure, COPD, or end-stage kidney disease 	2. Not selected for CCM program.	EHR, health risk assessment • Qualitative = clinician/CCM team clinical review, clinician referral, referral from care management intervention, inpatient case management, home health, and the medical neighborhood	
Hong ^{3,44}	Medicare and dual eligible patients at a primary care practice within Wishard Health Services (integrated delivery system)	Identify care sensitive, high-risk patients to include in complex care programs.	GRACE considers the following factors when identifying eligible patients: age/utilization, dual eligibility, high-risk diagnoses, and multifactorial risk assessment.	<ol style="list-style-type: none"> 1. Selected for CCM program 2. Not selected for CCM program 	Hybrid: • Quantitative = claims, EHRs • Qualitative = clinician referral	Authors did not describe specific resources to provide to high-risk patients.

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
Horn et al. ²⁰	High-cost (top 1 percent), medically complex patients at University of New Mexico's Health Sciences Center (public teaching hospital)	Evaluate the economic impact of Care One, an intensive care management program designed to target the most expensive 1 percent of patients in a university health care system.	<ol style="list-style-type: none"> Each month, the Care One team identifies the top 1 percent of high-cost patients for the previous twelve months. Evaluate each patient's needs and assess whether patients will be amenable to care through patient interviews and a review of medical records. A chosen subgroup is admitted to the Care One program. 	<ol style="list-style-type: none"> Selected for Care One program. Not selected for Care One Group. 	Hybrid: <ul style="list-style-type: none"> Quantitative = HSC's physician and hospital data, plus patient-specific data including billed charges, demographics, payer source, and comorbidities Qualitative = care team assessment and patient interviews 	Patients receive the following services while participating in Care One: <ul style="list-style-type: none"> Placement in primary care panel Specialist disease management Nurse care management Mental health services Social support Pharmacy support
Hostetter and Klein ⁶	Patients who may be at high risk for health problems and need additional help within Bellin Health (integrated delivery system)	Identify issues that may impact patients' engagement in their health.	<ol style="list-style-type: none"> Combine EHR data with other data sources (patient's address, insurance status, and medical billing status) for the entire patient population. Use data to group patients into four subgroups. 	<ol style="list-style-type: none"> HNHC patients who make use of the health system and may or may not benefit from additional oversight Those at very high risk who are not actively engaged Patients at low risk who nonetheless have high spending, often because of difficulty navigating the system Patients who are relatively healthy and have little interaction with the system 	Hybrid: (Hong ³) <ul style="list-style-type: none"> Quantitative = evidence-based risk score calculated from length of stay, acute admissions, comorbidity, ER visits score and readmissions data Qualitative = CCM team chart review, clinician referral 	Author did not identify which resources are provided to high-risk patients. Author mentions that Bellin's goal is to engage patients and leverage that engagement to maintain health.

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
Hsu et al. ³⁴	Medicare patients who were initially aligned with Partners ACO in 2012 or 2013 and had been identified in any year between 2012 and 2014 by their PCP as having potentially modifiable elevated risks for future spending and chose to participate in the CMP.	Examine how a Pioneer ACO alters utilization and spending for its aligned beneficiaries through participation in a CMP. (Refer to Vogeli ⁸ for more details about Partners Healthcare ACO.)	<ol style="list-style-type: none"> 1. Identify beneficiaries who appeared likely to be at high risk for future spending. 2. Select the subset of this group whose costs appeared to be modifiable, using information from each beneficiary's primary care physician. 	<ol style="list-style-type: none"> 1. Selected for care management program. 2. Not selected for care management program. 	Hybrid: <ul style="list-style-type: none"> • Quantitative = Medicare claims data • Qualitative = clinician referral 	Author did not identify which resources are provided to high-risk patients.
Institute for Healthcare Improvement ³¹	Patients with complex needs and high health care costs	Provide a structured approach for redesigning care for patients with complex needs and high health care costs	<ol style="list-style-type: none"> 1. Determine patient population to target for segmentation. 2. Choose population segment and learn about the root causes of high utilization and the assets that can be leveraged to improve outcomes. 3. Determine which subgroups will be most impacted by an enhanced care model. 4. Identify specific individuals within the chosen population by using multiple approaches (combination of qualitative and qualitative approaches). 5. Meet with primary care clinicians to review the list of patients who are in the population segment with complex needs and high costs. 	Authors did not develop specific subgroups.	Hybrid: Examples of data sources listed in the guide include the following: <ul style="list-style-type: none"> • Health care utilization data • Data from patient files • Patient survey data • Clinician referral 	Author did not suggest specific resources to provide to high-risk patients.

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
			<p>6. Meet 5 to 10 of the people identified through identification methods to determine whether the identification methods for choosing patients are a good fit for the model.</p>			
Johnson et al. ⁷	<p>Patients of all insurance types receiving care at DH (integrated safety-net health care system) from May 2011 to April 2013</p>	<p>Identify clinically meaningful and distinct subgroups within DH's patient population, which can be used by providers to target resources to specific patients.</p>	<ol style="list-style-type: none"> 1. Identify those patients who had three or more hospitalizations in a rolling twelve-month look-back period or had both a serious mental health diagnosis and two or more hospitalizations in that period 2. Identify the above criteria for each month of the study period. 3. Use the opportunity framework developed by Geraint Lewis to identify clinically relevant subgroups. This included literature-informed data mining to identify subpopulations of relatively homogenous patients for whom cost-effective interventions exist. 	<ol style="list-style-type: none"> 1. Recipients of emergency inpatient dialysis 2. Terminal cancer patients 3. Trauma patients 4. Orthopedic surgery patients (not trauma related) 5. Individuals with serious mental health diagnoses 6. Patients with multiple chronic diseases/other 	<p>Quantitative: Extracted clinical, demographic, and financial data on super-utilizers from DH's data warehouse</p>	<p>Segmentation was completed for purposes of the study. The authors did suggest that the following resources could be provided to patients:</p> <ul style="list-style-type: none"> • Embedding complex case management teams in regular primary care practices • Offering alternative models of care, such as ambulatory intensive caring unit models and home- and community-based approaches
Johnson et al. ¹¹	<p>Publicly insured and uninsured patients who receive or could benefit from primary care at a DH (integrated safety-net health care system) primary care clinic</p>	<p>Identify clinically meaningful and distinct subgroups within DH's patient population, which can be used by providers to target resources to specific patients.</p>	<ol style="list-style-type: none"> 1. Sort the patients using Clinical Risk Groups (CRG) 2. Assign specific CRGs to four tiers based on algorithmic rules and tier promotion criteria, including the likelihood patients will benefit from clinical pharmacist interventions, clinical actionability, and utilization criteria. 3. Clinical team reviews tiering assignments and aligned 	<ol style="list-style-type: none"> 1. Tier 1: CRG 1, 2, and a small percentage of 3 and 5 (healthy, history of significant acute disease, single minor chronic condition, and single dominant or moderate chronic condition) 2. Tier 2: CRG 3, 4, 5, 8, and 9 (single minor chronic condition, minor chronic disease in 	<p>Hybrid:</p> <ul style="list-style-type: none"> • Quantitative = clinical data from DH's data warehouse • Qualitative = physician review and input of algorithm assignments 	<ul style="list-style-type: none"> • Tier 1: Panel management (diet support, appointment reminders, integrated behavioral health, clinical social work) • Tier 2: Panel management, care management for chronic disease (diabetes/hypertension management, pharmacotherapy)

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
			<p>interventions for clinical coherence.</p>	<p>multiple organ systems, single dominant or moderate chronic condition, dominant metastatic and complicated malignancies, catastrophic conditions)</p> <p>3. Tier 3: CRG 5, 6, 7, and 9 (single dominant or moderate chronic condition, significant chronic conditions in multiple organ systems, and catastrophic conditions)</p> <p>4. Tier 4: CRG 7 (dominant chronic disease in three or more organ systems)</p>		<p>management, transitions of care coordination)</p> <ul style="list-style-type: none"> • Tier 3: Panel management, care management for chronic disease, complex case management (enhanced care teams including patient navigators, clinical pharmacists, behavioral health consultants and clinical social workers) • Tier 4: Panel management, care management for chronic disease, complex case management, high-intensity treatment teams (intensive outpatient clinic, mental health center of Denver)
<p>Joynt et al.²</p>	<p>High-cost patients in Medicare FFS population</p>	<p>Identify clinically meaningful and distinct subgroups, which can be used by providers to target resources to specific patients and reduce spending</p>	<ol style="list-style-type: none"> 1. Calculate annual cost for 20 percent of the Medicare population. 2. Classify high-cost patients as those in the highest 10 percent of spending. 3. Assign patients into the segments using a waterfall approach (groups are assigned 	<ol style="list-style-type: none"> 1. Under-65 disabled/end-stage renal disease 2. Frail elderly 3. Major complex chronic 4. Minor complex chronic 5. Simple chronic 6. Relatively healthy 	<p>Quantitative: Medicare FFS claims from 2011 (baseline year, used to determine comorbidities and subgroups) and 2012 (spending year)</p>	<p>Segmentation was completed for purposes of defining potential subgroups and did not suggest specific resources to provide to subgroups.</p>

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
			in hierarchal order and are mutually exclusive).	Exclusion criteria: The authors excluded the following subjects from the study: <ul style="list-style-type: none"> • Those with Medicare Advantage coverage for any portion of the study period • Those without continuous enrollment in Parts A or B during the study period • Those who died during the study period 		
Kelley et al. ²⁵	Medicare patients participating in the Health and Retirement Study (HRS) cohort who had continuous Medicare Parts A and B FFS coverage from 2002 to 2010	Identify clinically meaningful and distinct subgroups, which can be used by providers to target resources to specific patients and reduce spending.	<ol style="list-style-type: none"> 1. Using HRS cohort data, identify patients who meet eligibility criteria for the study. 2. Use Medicaid claims data to identify each subject's medical conditions, hospital admissions, and total Medicare spending. 3. Enroll patients in one of the predefined segments. 	<ol style="list-style-type: none"> 1. Condition and/or functional limitation (most broad): one or more severe medical conditions and/or receiving assistance with any of the six basic activities of daily living (ADL). 2. Condition and/or Functional Limitation and Utilization: one or more severe medical conditions and/or receiving assistance with any ADL and one or more hospital admission in the last 12 months and/or residing in a nursing home. 3. Condition and Functional Limitation and Utilization (most restricted): one or more severe medical conditions and receiving 	Quantitative: Medicare claims data (hospital admissions and total Medicare spending)	Authors did not suggest specific resources to provide to high-risk patients.

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
				assistance with any ADL and one or more hospital admission in the last 12 months and/or residing in a nursing home.		
Lewis ²⁶	High-risk patients	Use impactability models to identify patients at risk for unplanned hospitalizations and are amenable to preventative care.	<ul style="list-style-type: none"> • No details provided on how the organizations segment their population, beyond discussing the issue of impactability. (The term impactability is used to connote predictive modeling tools that consider the “actionability” of patients’ diseases and treatments.) • The programs use predictive impactability model to identify patients who are at high-risk for unplanned hospitalizations and are amenable to primary care interventions to prevent hospitalizations. Common ways to improve the impact of predictive models are: <ul style="list-style-type: none"> ○ Prioritize ambulatory-care sensitive conditions ○ Prioritize patients with a number of gaps in their care (e.g. patient with ischemic heart disease not taking an antiplatelet drug such as low dose aspirin) ○ De-prioritize patients with a history of noncompliance 	1. Impactible high-risk patients 2. Non-impactible high-risk patients Exclusion criteria: In some cases, disease management organizations excluded the “very high-risk” patients from their efforts because they felt that hospitalizations in this group can be difficult to prevent.	Quantitative: Administrative data	Author did not suggest specific resources to provide to high-risk patients.
Long et al. ³³	High-need patients	Identify key characteristics of high-need	The authors did not identify a segmentation process. They did note that when identifying high-	The authors developed subgroups based on medical characteristics:	The authors do not identify specific sources of data to	The assessment identified four dimensions of focus that constitute a possible

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
		patients, a starter taxonomy to target care, and promising care models and attributes to better serve high-need patients	need patients, simply looking at cost alone is insufficient. They mentioned that functional limitations are key drivers of need and that because medical care is only a relatively small portion of health, identifying inadequate access to social and behavioral services is critical as well.	<ol style="list-style-type: none"> 1.Children with complex needs 2.Non-elderly disabled 3.Multiple chronic 4.Major complex chronic 5.Frail elderly 6.Advancing illness <p>The authors also include behavioral (for example,. substance abuse or cognitive decline) and social (for example, housing insecurity or community deprivation) factors not as individual segments but as factors that influence the care model or care team composition most likely to benefit high-need patients.</p>	use for subgroup segmentation. Based on the authors' review of two taxonomies (which used claims data and clinical input) and an analysis of Medical Expenditure Panel Survey data to show the importance of behavioral health risk factors, both qualitative and quantitative data could assist in identification of high-need patients.	<p>analytical framework for identifying successful care models</p> <ol style="list-style-type: none"> 1. Focus of service setting – Settings include enhanced primary care and transitional care 2. Care attributes – Attributes include multi-dimensional patient assessments and evidence-based care planning 3. Delivery features – Features include 24/7 access to a multidisciplinary care team 4. Organizational culture – Features of the culture include use of multiple sources of data and leadership across levels
Lynn et al. ⁴ and review of Bridges to Health (Outcomes Based Healthcare ⁵)	Stockport Together Program, Stockport, England, people age 65 and older	Segment the whole population to gain a better understanding of how to achieve better health for both the individual and all people	Author did not describe how to conduct segmentation of HNHC patients into subgroups.	<p>Lynn et al.⁴ identified the following segments for the whole population. Segments 4–8 are most relevant for our review:</p> <ol style="list-style-type: none"> 1.Healthy 2.Maternal and infant health 3.Acutely ill 4.Chronic conditions, normal function 	<p>Hybrid: The data mentioned in the report are existing data coded in clinical or administrative systems used by health and social care organizations.</p> <p>The authors identified groupings of defining characteristics that</p>	Authors did not suggest specific resources to provide to high-risk patients.

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
				5. Stable but serious disability 6. Short period of decline before dying 7. Limited reserve and exacerbations (heart failure, COPD, renal failure, liver failure, neurological disease [e.g., Parkinson's, multiple sclerosis]) 8. Frailty, with or without dementia	can be used for segmentation. The groupings are <ul style="list-style-type: none"> • Person-centered <ul style="list-style-type: none"> ○ Health-specific ○ Person-specific • Social and economic related • Behavioral • System-focused Given the structure of the U.S. health care system, some of these groupings are more aspirational than others.	
Rinehart et al. ²⁷	Adult patients who had an admission at DH (integrated safety-net health care system) in 2014 and two or more admissions within the preceding 12 months	Identify clinically meaningful and distinct subgroups, which can be used by providers to target resources to specific patients and reduce spending.	1. Identify superutilizers as adult patients (> 18 years) who had a hospital admission during the study period (January 1, 2014–December 31, 2014) and had two or more admissions within the preceding 12 months of this index admission. 2. Obtain administrative data on clinical and service utilization variables of interest from DH's clinical and financial data warehouse. 3. Identify individual-level indicator variables that represented medical, mental health/substance use disorders	1. Class 1: Alcohol/homeless 2. Class 2: Medical, MH/SUDs, homeless 3. Class 3: Medical 4. Class 4: MH/drug use, homeless 5. Class 5: Medical (lower with some MH/SUDs) Exclusion criteria: Small group of patients requiring nearly weekly admissions for emergent dialysis, as these admissions are not preventable through	Quantitative: Administrative data on clinical and service utilization variables of interest from DH clinical and financial data warehouse	Segmentation was completed for purposes of the study. The authors suggested the following resources to provide patients in each segment: <ul style="list-style-type: none"> • Class 1: Community-based outreach services, or services embedded in an ED setting. Services should include multidisciplinary staff with a strong focus on housing, social support, and SUD services • Class 2: Optimized medical management

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
			<p>(MH/SUDs), and social conditions influencing overall health to include in the latent class analysis. Also in the analysis are demographic and visit-level data reflecting admissions, outpatient utilization, and total charges.</p> <p>4. Use the Elixhauser comorbidity software and the Clinical Classification Software system to create validated summary variables that group similar individual International Classification of Diseases (ninth revision) diagnosis codes.</p> <p>5. Use Mplus 7.1 software to run the LCA with the 30 identified dichotomous indicators and create five high-risk patient subgroups.</p>	<p>existing clinical financing options.</p>		<p>with alternative primary-care models (e.g., ambulatory intensive care unit)</p> <ul style="list-style-type: none"> • Class 3: Care coordination, patient navigation, or community health worker services embedded within the primary care setting • Class 4: Services either strongly aligned with or embedded within a formal MH treatment agency that also has co-occurring addiction expertise • Class 5: Screening in primary care and a strong linkage to MH and addiction services
<p>Vogeli et al.²¹</p>	<p>Medicare patients in the Partners Healthcare Medicare Pioneer ACO in 2013</p>	<p>Understand the characteristics of patients identified as high-risk for poor outcomes and describe the variation across PCPs in identifying and selecting patients for CMP. (Refer to Hsu et al.³⁴ for more</p>	<ol style="list-style-type: none"> 1. Use Optum ImpactPro to assign patients a risk score for future total medical expenses. 2. Among patients with risk scores that exceed a minimum threshold, use Partners' algorithm, which incorporates data about chronic conditions and patterns of health care utilization, to identify patients as high-risk and appropriate for clinical review. 3. PCPs review the list generated by the algorithm to assess 	<p>Authors did not note specific subgroups.</p> <p>Exclusion criteria: Examples include patients who had moved, died before the review process, were not community dwelling (e.g., residing in long-term care), switched to a Medicare Advantage plan, or did not have a relationship with a Partners primary care clinician</p>	<p>Hybrid:</p> <ul style="list-style-type: none"> • Quantitative = clinical data • Qualitative = PCP review of list of potential high-risk patients 	<p>Authors did not suggest specific resources to provide to high-risk patients.</p>

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
		details about Partners ACO.)	whether a patient is in fact high risk and should be selected for a CMP.			
Vuik et al. ²⁸	Patients receiving care in the Valencia region of Spain. Of the three programs reviewed, the ValCronic program used segmentation to identify subgroups.	Prevent complications of long-term conditions.	<ol style="list-style-type: none"> 1. Identify patients with the following long-term conditions: type 2 diabetes, COPD, heart failure, and hypertension. 2. Risk-stratify patients using the Clinical Risk Group stratification method. 3. Segment patients within each risk score by individual and combination of long-term conditions. 	Authors did not note specific subgroups.	Hybrid: Quantitative = demographic data, information about vaccinations, and hospital discharge data Qualitative = data from primary care and prescribing providers in the electronic primary care record	The level of risk determines the intensity of the program intervention. High-risk patients receive the following resources: <ul style="list-style-type: none"> • Tablet personal computer for communicating with PCP • Disease-specific biometric device • Education and support for self-care The program provides lower-risk segments with communication and education through a web portal.
Zhou et al. ²²	Medicare patients 65 years or older who receive care from Kaiser Permanente (integrated managed care organization)	Identify clinically meaningful and distinct subgroups within the senior population, which can be used by providers to target resources to specific patients and reduce spending.	<ol style="list-style-type: none"> 1. The authors developed the Senior Segmentation Algorithm by establishing simple rules using risk scores and clinical criteria. 2. Using the first iteration of the rules, the Kaiser team took patients in PCP panels and categorized them into care groups for PCPs to review and provide feedback. 3. On the basis of PCP feedback, the Kaiser team added, deleted, 	<ol style="list-style-type: none"> 1. Care Group 1: Robust seniors without chronic conditions Exclusion criteria: Examples include HIV/AIDs, dementia, Alzheimer disease, and stroke. <ol style="list-style-type: none"> 2. Care Group 2: Seniors with one or more chronic conditions, such as diabetes, heart disease, or depression 	Hybrid: <ul style="list-style-type: none"> • Quantitative = clinical data from Kaiser’s EHRs, chronic conditions diagnoses and utilization data, prospective risk scores, and likelihood of hospitalization risk scores • Qualitative = physician review and input of 	Segmentation was completed for purposes of the study. The authors suggested the following resources to provide patients in each segment: <ul style="list-style-type: none"> • Care Group 1: Disease prevention, screening, and health promotion services • Care Group 2: Disease management • Care Group 3: Complex case management, advanced illness

Author, program*	Target population	Targeted outcomes	Segmentation process	Subgroups	Data sources	Resources provided to subgroups
			and tailored rules to reflect physician judgment. 4. The team then used the updated algorithm to assign senior patients into care groups. 5. Physicians reviewed results from the algorithm to assess whether the algorithm categorized their patients correctly.	Exclusion criteria: Severe organ failure, stroke, selected cancers. 3. Care Group 3: Seniors with advanced illness and end-organ failure, such as heart failure or COPD 4. Care Group 4: Seniors with advanced frailty or at the end of life	algorithm assignments	coordinated care, transitional care, guided care, and geriatric consultation <ul style="list-style-type: none"> Care Group 4: Home-based care, social work outreach, guided care, palliative care, and hospice care

*The number of rows in Table 3 is greater than the number of rows in Table 2 because some papers described multiple programs.

†Two of the three programs mentioned in Table 2 are included under Hong. The third program, Denver Health, was mentioned in detail in publications by authors from Denver Health and are therefore included under those authors' names (Johnson^{11,24} and Rinehart²⁷).

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