A Population Health Management Approach in the Home and Community-based Settings

Mark Emery
Linda Schertzer
Kyle Vice
Charles Lagor

Philips Home Monitoring

Executive Summary

Philips is exploring technologies and services for the home and community-based settings to address the needs of health care organizations under the health care reform. In this white paper, we present one of our concepts. Our goal is to stimulate a discussion and together with the health care community, develop solutions that provide patient-centered care while improving the overall care of the population.

Introduction

Under the health care reform in the United States, health care organizations are increasingly taking the responsibility for managing entire patient populations. In doing so, they face the problem that their patients are outside of the hospital most of the time, and that they have little insight into the health status of their patients, the support network that they have (or lack thereof), and the care or support services they receive. Remote health management offerings such as personal emergency response systems (PERS), medication dispensers, and telemonitoring solutions, are important components for elucidating the health status of individual patients. However, devices and their data alone are insufficient for managing patient populations. In order to effectively manage health and financial risks for patient populations, health care organizations need to link outcomes measured at the population level to data collected at the individual care level, especially data collected in the home and community-based settings. Population-level outcomes inform health care leaders *if* there is a problem, whereas care-level data inform them *where* the problem originates. Linking the two information levels allows health care leaders to effectively intervene in order to affect key population health performance indicators. In this white paper, we present a comprehensive population health management approach that leverages the data collected in the home and community-based settings through sophisticated analytics.

Overview of a Comprehensive Population Health Management Approach in the Home and Community-Based Settings

The premise of the population management approach described in this paper can be summarized as follows: insights derived from *integrated* remote health management data[1] are crucial to population health management efforts of health care organizations. The analyzed data provide both *clinical* insights for entire patient populations, as well as *operational* insights to better manage populations. Moreover, integrated data provide the means for developing clinical decision support tools for individual patient care.

The approach is “comprehensive” in that it links information from a population level with information from the patient level. Both levels influence one another: insights obtained from

[1] Remote health management data are health-related data collected in patients’ homes, primary physicians’ offices, home health care agencies, and other care providers, including long-term and post-acute care providers. Examples include data collected from PERS, medication dispensers, and telemonitoring solutions.

population level analyses impact individual patient care, and insights obtained at the individual care level influence strategic decisions at the population level. Figure 1 gives a functional overview of the comprehensive population health management approach. The approach begins by stratifying an entire patient population into sub-populations (step 1). Different stratification approaches can be taken: by disease, by disease severity, by costs incurred, and so on. The purpose of stratifying patients is to identify those sub-populations that need the greatest attention.

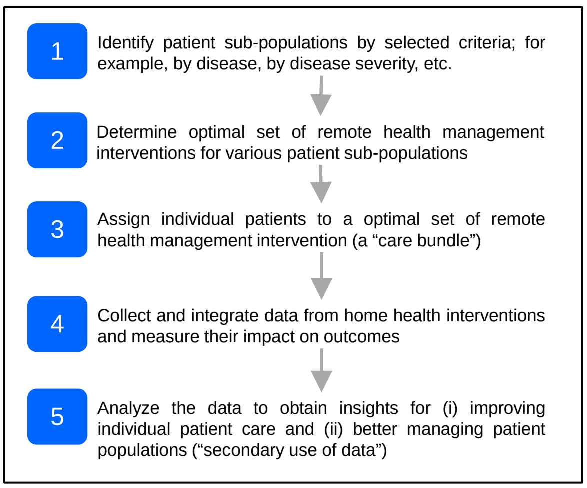

Figure 1. Overview of the Population Health Management Approach

In step 2 one determines the optimal remote health management interventions for the identified patient sub-populations. We define a remote health management intervention as any technology or process implemented in the home and community-based settings that potentially impacts health outcomes. A remote health management intervention can be a device, a survey, a computer application, or a standardized care path usually coupled with a service. The decision as to which set of interventions a patient population needs to be on is driven by clinical and financial considerations.

Once a remote health management intervention strategy for a particular patient sub-population has been agreed upon, it needs to be implemented. This means that every patient in a particular sub-population needs to be assigned to an optimal combination of remote health management interventions (step 3). The assessment of which patient needs which remote health management interventions is granular and goes beyond just merely determining if the patient belongs to a particular patient sub-population.

Data collection begins as soon as remote health management interventions have been installed for individual patients (step 4). Each remote health management intervention is a data source. Hence, data are collected whenever a patient, a caregiver, or a clinician interacts with an intervention. The collected data are either clinical (for example, blood pressure measurement) or operational (for example, the time the blood pressure measurement was taken). They are also generated through interventions by clinicians (for example, electronically documenting a change in the medication regimen). In addition to clinical and operational data, quality metrics data – such as mortality, 30-day readmission rate – are collected, in order to assess the clinical efficacy of the remote health management interventions. The quality metrics data come from the health care organizations information system (electronic medical record or billing system).

All of the collected data are reconciled in a common database and subsequently analyzed (step 5). As mentioned previously, the premise of the population health management approach is: "insights derived from integrated remote health management data are crucial to population health management efforts." The analyzed data are valuable at both the patient and population level. At the patient level, the data are used to develop decision support applications that help manage individual patients. At the population level, the data provide insights that help improve population health management strategies.

The steps of the approach align with different phases of a population health management initiative. Steps 1 and 2 are part of designing a population health management initiative. They are strategic in nature and therefore take place at the health care leadership level. Steps 3 and 4 are part of executing a population health management initiative at the patient care level. They involve patients, caregivers, and clinicians as key stakeholders. Step 5, the data analysis, involves individuals with specialized skill sets. This step aligns with assessing the impact of a population health management initiative. It goes beyond just assessing the impact, because the *secondary use* of the data[2] yields insights and tools that will improve future patient care and population management. Hence, the approach is iterative since step 5 closes the loop with step 1.

Components of the Population Health Management Approach

The previous section focused on the question "*What* is the comprehensive population health management approach in the home and community-based settings?" This section focuses on the question "*How* does the approach work?" The components or tools described in this section are grouped according to the information level they serve – i.e. population or individual patient – and according to the phase in the remote health management data collection process – i.e. pre-data collection, data collection, and post-data collection.

Components at the Population Level, pre Data Collection

Step 1 is stratifying a patient population into sub-populations. There are multiple ways of segmenting patient populations:

- By disease (e.g. congestive heart failure, chronic obstructive pulmonary disease, diabetes…etc.)
- By severity scores (e.g. New York Heart Association functional classification of heart failure)
- By risk (e.g. 30-day readmission risk, risk of falling…etc.)
- By financial considerations (e.g. top 5% of most expensive patients)
- By consumption of health care services (e.g. number of previous hospitalizations)

The tools at this step can be as simple as a database query; for example, "return all patients who are older than 65, have had more than 2 hospitalizations, and are on more than 4 medications." They can be as complex as a logistic regression model[3] with 50 independent (or input) variables (step 1 in Figure 2). In either case, the outputs of the tools are descriptive statistics on a population; i.e. the proportions of different patient strata.

[2] Secondary use of data refers to using data for purposes other than the original intent. An example of secondary use is analyzing data from a blood pressure device to derive insights about the compliance of patients with self-monitoring.

[3] Logistic regression analysis is one of many statistical modeling techniques.

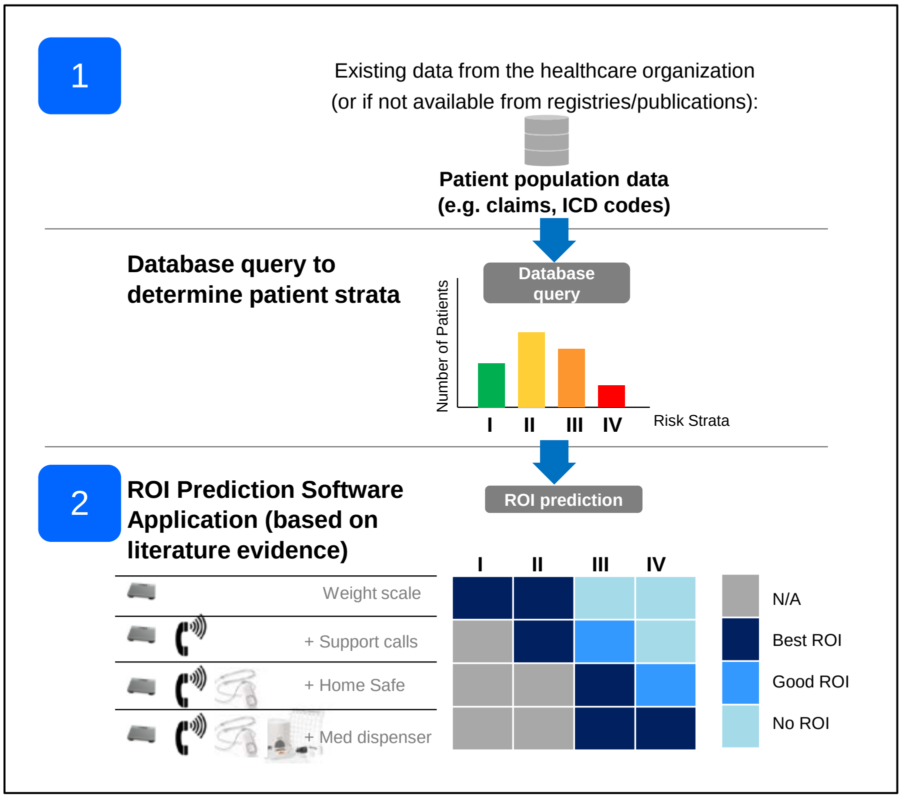

Figure 2. Components at the Population Level, pre Data Collection (illustrated using patients with Congestive Heart Failure as an example)

The descriptive statistics provide the basis for the second step, in which one identifies an optimal remote health management intervention strategy for each patient sub-population. Again, tools are a critical component. Whereas the tools in step 1 may vary in complexity, the tools in step 2 are based on sophisticated methods – for example Markov-models[4] – because they need to predict the clinical and financial outcomes of the interventions for different patient sub-populations (Step 2 in Figure 2). For such predictions, the tools require the following types of input variables:

- proportions of the patient sub-groups,
- clinical efficacy of interventions, and
- cost of interventions

With these input variables, the tools simulate and compare the courses of events for patients with and without interventions, thereby estimating the benefit of the interventions and their return on investment (ROI).

Ideally, the input data are derived from the health care organizations' billing systems or electronic medical records. In reality, the required input data may not always be readily available; especially, if a health care

[4] A Markov model is a mathematical model that calculates the likelihood of transitioning from one state to another. For example, a Markov model can simulate patients transitioning from one hospitalization to a second hospitalization.

organization has not collected data from remote health management interventions. Under these circumstances, one can resort to using data from comparable organizations that have used these interventions or peer-reviewed journals. The resulting predictions might not be as accurate for a particular organization as those predictions that are based on the organization's own data. However, they are a reasonable first step: once an organization has implemented remote health management interventions and collected data, the prediction tool can be run again with new input data.

Components at the Patient Level, Data Collection

The third step, assigning a patient to an optimal set or bundle of interventions, requires tools that predict and compare the outcomes for a patient under different levels of interventions. The tools are similar to the ones in step 2 in that they help identify an optimal set of interventions. Like their population level counterparts, they take into consideration the clinical efficacy and cost of interventions.

Despite the similarities, however, one cannot simply re-use the prediction tools from step 2. Unlike the population level tools, which may use data from other organizations or peer-reviewed journals as inputs, the tools in this phase depend on individual patient data because they provide recommendations that are customized to a particular patient.

Individual patient data include demographic data, clinical data, and socio-economic data. The input data are collected through an electronic questionnaire, which may be pre-populated with data from the electronic medical record (Step 3 in Figure 3). The tool analyzes the entered data and recommends an optimal set of interventions.

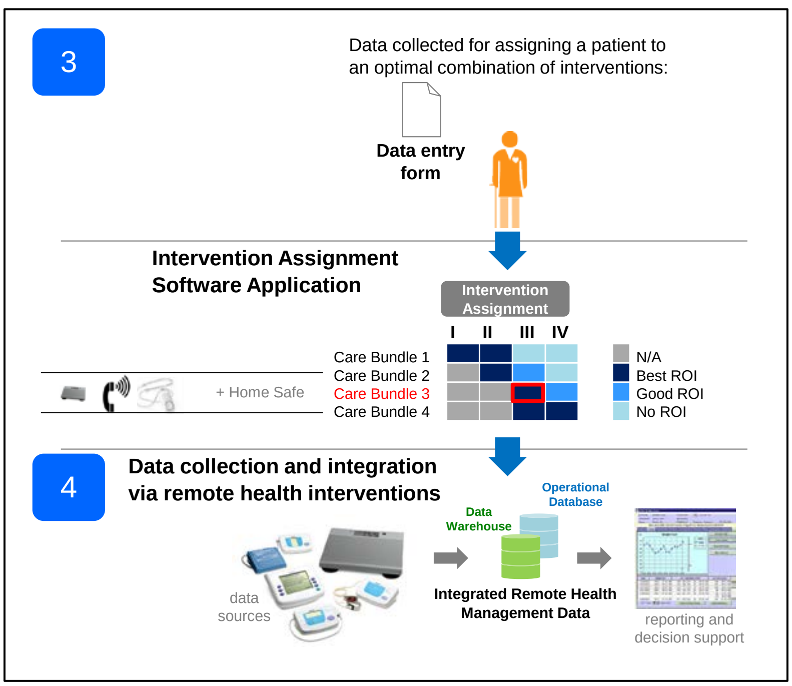

Figure 3. Components at the Patient Level, Data Collection

Once a particular set of interventions are in place, data are collected through various data sources: tele-health devices, medication dispensers, electronic surveys, and so on (step 4 in Figure 3). According to the premise that integrated remote health management data are crucial to population health management efforts, different data streams are reconciled in databases. Hence, the tools of step 4 include the databases that store the integrated data. There are two main types of databases that store integrated remote health management data:

1. The *operational database* is used to carry out routine tasks in clinical care. It supports functionalities such as generating alerts or plotting clinical variables for individual patients. Data integration within the operational database plays a role when clinical decision support applications require data from different sources to provide recommendations in real-time.
2. The *data warehouse* is designed to support reporting and data analyses. It is kept separately from the operational environment so as not to interfere with the routine patient care. As described in the next sections, the analyses of the integrated data drive the development of the aforementioned clinical decision support applications, as well as population health management tools.

The tools of step 4 also include the means to view the results of database queries, i.e. reports and dashboards. A clinical plot of the glucose values monitored for one diabetic patient at home is an example of a reporting functionality that is supported by the operational database. A histogram showing how often managed diabetic patients measure their glucose in a week is an example of a reporting functionality that is supported by the data warehouse.

Components at the Patient Level, Post-data Collection

Although reporting is an important functionality, the true value of integrated remote health management data is attained through their secondary use, which has a greater potential impact on population health management. There are different types of secondary use depending on the desired application of the data; for example, developing clinical decision support tools to improve patient care, or analyzing data to support strategic decisions. The question of which secondary uses to pursue is part of the population health management strategy, and it is continuously addressed as new insights from the data potentially warrant further secondary uses.

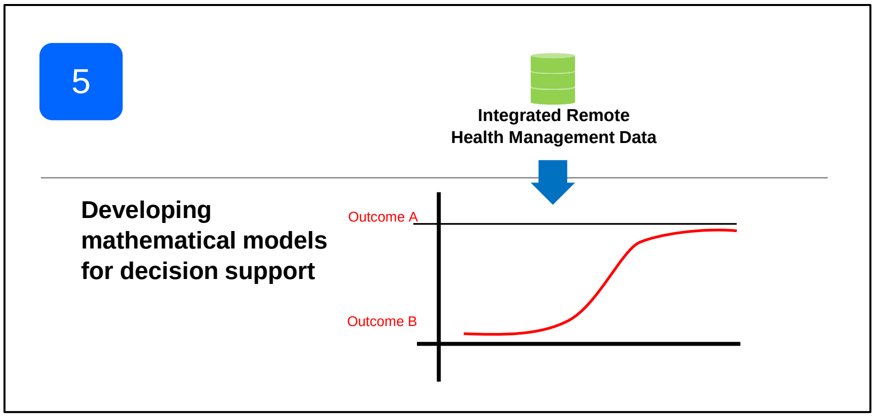

Figure 4. Components at the Patient Level, post Data Collection

At the patient level, the secondary use of data typically involves developing a decision support tool (Figure 4). For example, part of an organization's population health management strategy might be to develop a decision support tool that predicts COPD[5] exacerbations for individual patients, with the goal of reducing the number of hospitalizations for the COPD patient population. After a few months of data collection from portable oxygen concentrators, medication dispensers, surveys, and other interventions, the development of the tool begins with preliminary statistical analyses. A modeling approach is selected and prototypes are built and tested. The final decision support tool is eventually treated as an intervention, whose clinical efficacy can be measured.

Components at the Population Level, Post-data Collection

Whereas the goal of secondary data use at the patient level is to improve the care of individual patients, the goal at the population level is to improve the care of patient populations. There are different areas, where secondary use of integrated remote health management data supports population health management:

- **Clinical.** Statistical analyses of integrated clinical data reveal insights about the health status of patient populations. Consider an example where clinical data analysis reveals high variability of the mean blood glucose values of a group of patients within the elderly diabetic population. Further analyses that include data from activity monitoring devices, medication dispensers, and indicate that low compliance with medications or exercise regimens is the main reason for poorly managed diabetes in that particular group.
- **Operational**. Operational information is gathered whenever patients use their monitoring devices, whenever they fill out a survey, or whenever their care providers review their status through a web portal. The answers to the questions *Who, What, When, and Where* allow the recreation of a course of events for individual patients. These courses of events can be aggregated to the population level and analyzed for patterns. The patterns show whether particular care paths are followed in a consistent manner or whether there is variation in the care provided.
- **Quality.** Clinical outcomes metrics are compared to benchmarks and thus give an

[5] COPD, Chronic Obstructive Pulmonary Disease

indication of the impact of remote health management interventions. External benchmarks allow an organization to compare itself to national standards. Internal benchmarks allow an organization to investigate to what degree individual sites are benefiting from an intervention. Therefore they allow for a more accurate interpretation of the overall impact of an intervention. For example, the overall outcomes of an intervention would be lower than expected if some sites departed from the recommended enrollment path by placing ineligible patients on an intervention.

- **Financial.** In addition to demonstrating clinical benefits of an intervention, it is also important to demonstrate its financial benefits. Statistical analyses of outcomes and cost data show whether the measured ROI of an intervention matches the ROI predicted by the tools in step 2. Moreover, the ROI tools in step 2, which initially rely on data from other organizations or the literature, can be calibrated with data specific to an organization thereby making future ROI predictions more accurate.

Ultimately, the secondary use of data closes the loop with the initial steps of the comprehensive population health management approach. As analyses of data are likely to reveal new insights, new remote health management strategies are formulated to develop new interventions or improve existing ones. The new interventions are implemented and more integrated data are collected. The data are analyzed to reveal further insights, and so the cycle of continuous quality improvement starts again.

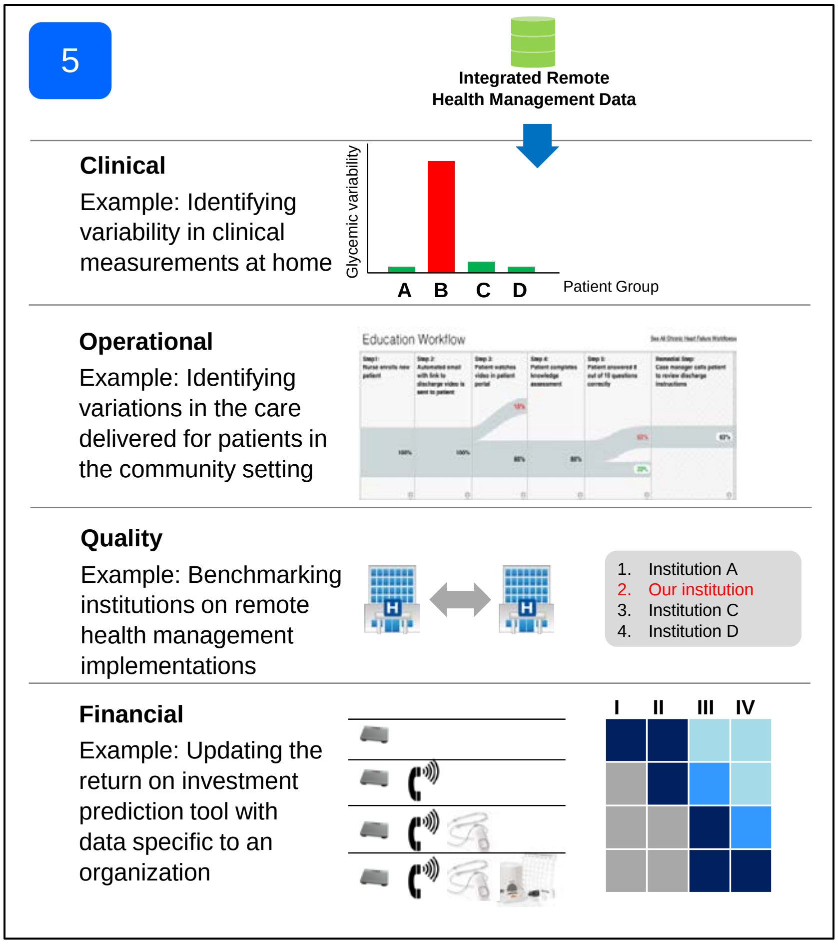

Figure 5. Components at the Population Level, post Data Collection

Use Case Scenarios

The following section illustrates the population health management approach in the home and community-based settings though a few use case scenarios. Each use case scenario is structured according to the steps outlined in Figure 1. It should be noted that the use case scenarios are just meant for illustration purposes and do not describe actual implementations.

Congestive Heart Failure Population Health Scenario

Step 1. In this example, a health care organization identifies Congestive Heart Failure (CHF) readmissions as the largest group among various cost contributors. The health care leaders set a target for reducing CHF readmissions from 25% to 15%, based on hospital readmission rates imposed by the Hospital Readmissions Reduction Program. The organization's health care information system is queried to generate a report on the proportions of CHF patients within the four NYHA[6] heart failure classes. The report also includes the number of hospital admissions within each NYHA class.

Step 2. The proportions of patients queried in Step 1 are entered into a tool that predicts the

[6] NYHA, New York Heart Association

ROI for remote health management interventions. The tool is based on a Markov-model, and simulates readmission and death events for patients with and without interventions. Other inputs include the costs and the clinical efficacy of the interventions. The clinical efficacy parameters are obtained from other providers who implemented these interventions or the peer-reviewed literature; they will eventually be replaced by clinical efficacy measurements once the interventions are implemented and data have been collected locally (see step 5). The health care leaders use the tools to run different scenarios, and eventually decide that the following intervention bundles provide the optimal clinical outcomes and ROI for their patients:

- NYHA class I patients: weight scale
- NYHA class II patients: weight scale and support calls
- NYHA class III patients: weight scale, support calls, and PERS
- NYHA class IV patients: weight scale, support calls, PERS, and medication dispenser

Step 3. To execute the CHF strategy, the health care organization implements a process in which a nurse assigns eligible CHF patients to remote health management interventions upon discharge. The nurse uses an electronic tool based on a mathematical model that calculates the reduction of CHF readmission risk under different intervention bundles for each patient. He/she enters an individual's demographic, clinical, and socio-economic input data required by the tool's data entry form, and then obtains a recommendation for the optimal remote health management interventions.

Step 4. Whenever a patient utilizes his/her assigned devices (weight scale, PERS, and medication dispenser) or services (support calls), both clinically relevant data (weight, blood pressure, reason for call etc.) as well as operational data (time of measurement, time of call, recommended clinical intervention, etc.) are collected and stored in a data warehouse. Furthermore, readmission data (date and time of readmission, reason for readmission) are captured each time a patient has been readmitted to the hospital.

Step 5. A few months after having implemented the different intervention bundles for CHF patients, the readmissions declined only to 20% instead of the originally targeted 15%. An analysis of the integrated remote health management data reveals that a significantly high proportion of patients with one or more readmissions in classes II and III did not take their medications as prescribed. The ROI estimation tool is re-calibrated with the clinical efficacy data collected during the past months, and new simulations suggest re-allocating the medication dispensing units to the affected patients.

COPD Education Use Case Scenario

Step 1. A health care organization analyzes the causes of exacerbations of COPD patients that could potentially be influenced through behavior change. A variety of reasons emerge: the patients continued with unhealthy habits such as smoking, the patients did not master using their nebulizer, or the patients were not motivated to adhere to their medication regimen. The health care organization uses the different categories of behavioral reasons as a means to stratify their COPD patients. The percentages for the different patient groups are summarized in a report.

Step 2. As in the CHF example, the health care leaders use a tool to predict the impact and ROI of a variety of educational interventions on patient behavior and ultimately on the frequency of exacerbations. The educational interventions include customizable reading materials to different learning preferences, educational videos, group education sessions, and nurse calls. After having entered the proportions of patient groups from step 2, they define various bundles of educational interventions. To ensure a successful implementation of these bundles, the health care organization has partnered with a variety of community-based organizations that support the educational program.

Step 3. Before discharge from the hospital, COPD patients are assigned to an optimal education intervention bundle. A nurse assesses how to best reach and motivate each patient by using an electronic tool that determines the patient's learning profile. The tool takes into account the particular situation of each patient and provides a recommendation for an educational intervention that is tailored to the patient.

Step 4. The educational interventions are implemented electronically, or at least have some electronic means of capturing whether educational material was absorbed. When the patients read or hear various types of materials, view educational videos, or obtain nurse calls, data that provide insights to each intervention are collected. These data include the completion of the tasks, their duration, or patterns on how the patients interacted with the material. Furthermore, patients are asked to complete surveys that indicate to what extent they understood the materials and to what extent they were motivated. Finally, data on the frequency of exacerbations are collected. All data are reconciled in a data warehouse.

Step 5. The data are analyzed after a few months into the program, revealing a significant prolongation in between COPD exacerbations, as well as reduction in the hospitalization rate. Survey results show that the patients are overall pleased with the educational interventions. A sub-group of patient, however, still finds it hard to stop smoking. An analysis of this sub-group suggests that these patients might have benefited from having the nurse call them more frequently. The insights provided through the data are eventually used to modify the educational interventions and to determine their clinical efficacy.

Conclusion

In this white paper, we present a comprehensive population health management approach in the home and community-based settings. It is based on the premise that integrated remote health management data are crucial to population health management efforts. The approach can be described in five steps that follow the clinical quality improvement cycle:

1. Identify patient sub-populations
2. Determine optimal set of remote health management interventions for various patient sub-populations
3. Assign individual patients to an optimal set of remote health management interventions
4. Integrate data from home health interventions and measure their impact on outcomes

5. Analyze the data to improve individual patient care and better manage patient populations.

Each step requires a set of information technology components that range from simple database queries to complex mathematical models.

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