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| **Title:** | Self-Management & Reminders with Technology: SMART Appraisal of an Integrated PHR |
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| **Project Officer:** | Vera Rosenthal, MPH |
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**Abstract:**

**Purpose**: This grant evaluated the impact of an active personal health record (PHR) to improve the care of patients at high risk for cardiovascular disease by increasing compliance to care recommendations.

**Scope**: Patients who had either cardiovascular disease or two risk factors for the development of cardiovascular disease and who spoke English and had access to a computer were eligible for participation.

**Methods**: We designed and developed an active and interactive PHR used by UPMC ambulatory practices. We conducted a randomized controlled trial of patients who had recently opened accounts in the UPMC PHR between the two versions of the PHR. Primary outcomes were closure of prevention and treatment gaps compared between the intervention and control group, secondary outcomes included calculations of 10-year cardiovascular risk, changes in cardiovascular risk prediction biomarkers, and patient satisfaction and barriers to use of a PHR.

**Results**: Patients engaged the active PHR and responded to requests for prevention and treatment gap closure, but there was no difference in gap closure rates at one year between the intervention and control group. There was improvement in gap closure rates for patients in practices that were in the lower quartile of compliance to guidelines. Patients are quite willing to engage in their own personal health, and found the active and interactive version of the PHR to be a significant improvement in the way they could participate in their own care and communicate with their care providers.

**Key Words**: electronic health record, personal health record, cardiovascular disease, patient activation

**Purpose** (Objectives of the study)

This project was designed to improve health care outcomes in complex patients with cardiovascular disease, or who are at high risk for developing cardiovascular disease, by promoting patient self-management through the use of an active and interactive personal health record (PHR) integrated into an electronic health record (EHR). The project included three specific aims design to build, test and evaluate such a program:

**Aim 1: Develop a patient-specific, active component to an existing electronic PHR directed towards patients with complex illnesses that is designed to reduce the risk of cardiovascular disease**,

**Aim 2: Conduct a randomized controlled trial of the effectiveness of passive and active PHRs for improving adherence and clinical outcomes of complex patients in an ambulatory environment**,

**Aim 3: Enumerate the barriers and facilitators to implementation and use of an electronic PHR among providers and patients in an ambulatory setting.**

Our goal was to develop the specific structure of the application in collaboration with the patients who would use it, to conduct a trial of its effectiveness in a real world setting, and during the conduct of the trial, assess through focus groups the facilitators and barriers to use of such an application.

Although the results of trial were primarily negative (overall, users of the active PHR did not reduce their cardiovascular risk at 1 year over the control group), the collaborative creation of the application, the analysis of the intensity of use of the application, and the focus group evaluation of the SMART PHR has expanded significant our knowledge about how to design, develop, and deploy more active patient-centered application within a PHR.

**Scope** (Background, Context, Settings, Participants, Incidence, Prevalence)

***The prevalence of complex patients with high cardiovascular risk is increasing:***

Cardiovascular disease (CVD) is the leading cause of mortality in the US, resulting in 652,486 deaths in 2005.[1] Moreover, patients with CVD or with multiple risk factors for CVD are increasing in the US, primarily because of the aging of the population.[1] There are multiple other risk factors for the development of CVD, and many of these, such as elevated lipids, hypertension, obesity and diabetes, are amenable to preventive and therapeutic interventions. Physicians are taking care of patients with increasingly complex health problems that make clinical decision-making difficult. The number of patients over 65 with 3 or more diagnoses has been increasing, and the number of chronic conditions increases as the population ages.[2] The presence of multiple comorbid conditions often produces situations in which the optimal care of one disease is limited or even contraindicated by another. Therefore, because the number of patients with multiple risk factors for CVD is increasing, and many of these risk factors can be mitigated through prevention and treatment, we will use cardiovascular risk reduction in complex patients as the target for an information technology-based patient self-management intervention.

***Current practice does not achieve guideline-recommended care****:*

Over the past several years, there has been increasing interest in evidence-based care as evidence accumulates that appropriate preventive and therapeutic interventions are not routinely provided.[3-5] Although much research has been directed at the evaluation of care of single disease processes, there is compelling evidence that the problem is worse for complex patients with multiple diseases.[6] As a result, patients with multiple complex diseases do not receive appropriate preventive care nor receive appropriate therapies for chronic conditions such as diabetes, heart disease, congestive heart failure and others.[6-13]

***Patient self-management can improve outcomes***

There is growing evidence that increased patient participation in the management of their own diseases improves clinical outcomes. One of the first diseases in which self-management was found to play an important role was diabetes,[14] perhaps because of the extent of patient-directed activities (e.g., insulin injections, glucose determinations) required for high quality treatment. Furthermore, there are several characteristics of self-management programs that are important aspects of our proposed development. The importance of patient-directed motivation was demonstrated by Hibbard, who found that “activated” patients were much more likely to have successful disease treatment.[15]. It has also been demonstrated in a meta-analysis that self-management is effective in elderly populations,[16] an important finding because a large number of patients with complex medical illness are elderly.

***Information technology can improve outcomes:***

Improved access to HIT has been shown to result in more educated patients and improved outcomes.[17,18] However, while experts agree that HIT is critical to transforming the health care industry, the adoption of HIT by clinician and patient disciplines has been limited and associated with difficulties.[19] The quality of HIT varies and often is not readily available in appropriate formats for patients (literacy level, language, etc). Patients also need to be aware of and educated regarding reputable on-line information venues as the quality of medical information on-line varies.[20,21]

Carolyn Clancy, MD, AHRQ Administrator, stated at a 2005 Patient Safety and HIT conference that “the way to achieve care and safety goals is to practice, innovate, assess, readjust, and practice some more.” Taking a patient-centered approach to using HIT efficiently is critical to the success and sustainability of these programs. From a provider standpoint, HIT has demonstrated benefits in increasing patient adherence to guidelines or protocol-based care, improving quality of care through clinical monitoring, and decreasing medication errors.[19] HIT benefits to patients include simplifying navigation of the health care delivery system (refill

prescriptions on-line, schedule appointments, etc), increasing access to clinical information, and increasing the ability to communicate with providers.[22] However, to ensure success, programs and processes have to meet the needs of the patient, clinician, and the health care system. Patient education supplied through HIT at the point of care may improve communication lines, strengthen patient/provider relationships, and allow more educated questions and dialogue to ensue at the clinical encounter.[17] A patient-centered approach needs to include novel venues of patient education and provider information through enhanced HIT.[23]

***Personal Health Records (PHRs) may engage patients in their care.***

There is some early evidence that patients who engage with their PHR (or similar on-line tools) experience improved health, with reports of improved outcomes in diabetes, [24] weight loss,[25] and preventive medicine gaps[26] There has been substantial interest in the electronic health record community and among consumers to use this technology. [27] In fact, a recent survey found that nearly 90% of patients surveyed would prefer online tools that could help them manage their own disease.[28]

***Patient Acceptance and use of PHRs***

Although there are well-known barriers to the use of electronic resources including PHRs,[29-32] acceptance and use continues to rise. In our own work, we have found a rapid increase in the number of patients who have signed up for the UPMC PHS (HealthTrak) and we have found general acceptance of the tools that they provide.[26,33] However, we have found that patients are concerned and express worry when information in the PHR is incorrect, or is not up-to-date and complete. For this reason, one of the major design features that we are incorporating into SMARTER PHR is the ability of the patient to tailor and modify (sometimes in consultation with the patient's provider), which information and which lifestyle activities the patient chooses to be reminded of.

***Summary:***

Chronic conditions are increasing in the US, and care of patients with chronic conditions is sub-optimal. Current reliance on physician-directed guidelines has not been as effective as hoped, and many chronic conditions may have better outcomes when patients are actively involved in their own self-management. Information technology and, specifically, the use of PHRs to activate and inform patients have substantial potential to improve care outcomes in the prevention and treatment of chronic disease.

In this work, we investigated the impact on of an active and interactive personal health record on ambulatory patient's with (or with high risk for) cardiovascular disease

**Methods** (Study Design, Data Sources/Collection, Interventions, Measures, Limitations)

***Study Design***: Randomized controlled trial of patients with either cardiovascular disease or high risk for cardiovascular disease. Patients who are 18 to 75 years old were eligible for the study if they had medically complex diseases that increase cardiovascular risk, and were not yet a PHR user. For the purposes of this project, patients were defined as meeting this criterion if they had known cardiovascular disease based on the presence of a diagnosis of CVD in the patients' chart, or they had two of the qualifying diseases associated with increased cardiovascular risk and they were taking at least one medication requiring periodic blood test monitoring for effectiveness or toxicity (e.g., hypoglycemic agents, diuretics or lipid-lowering medications). A list of the ICD-9 diagnoses of eligible diseases is provided in the Appendix at the end.)

While we initially planned to recruit eligible patients from 4 large UPMC practices that had agreed to become test sites, we needed to modify our recruitment plan because of two issues that arose after the original writing of the grant. First, the practices that already had Epic installed were having a much higher than predicted rate of patients signing up for HealthTrak, and we were not going to be able to recruit sufficient "PHR-naïve" patients. Second, the UPMC roll-out of both Epic and HealthTrak occurred at a faster pace than expected, and we were unable to find sufficient patients who had not already signed up for HealthTrak. Consequently, we expanded the recruitment criteria as follows:

- We expanded the potential study sites to include any UPMC practice that was currently using Epic (75 practices)
- We relaxed the "Epic naïve" requirement to allow patients who signed up for HealthTrak within 6 months were still eligible to participate.

***Data Sources/Collection***:
The primary data source for the RCT was the EHR itself, from which we obtained all of the primary outcomes.

*Clinical Disease Outcomes*: All of the primary outcome variables were collected directly through the EMR as a byproduct of care. All of the outcomes (prevention gaps, laboratory values, blood pressure) are continuously collected over time by the EMR system. We electronically evaluated each study participant's chart at 6 month intervals. For patients who appeared to be missing certain data points, the electronic chart was reviewed by the research assistant. If the expected results were not found within the chart, and the participant had provided permission to obtain records from any outside providers, we could request any available records pertaining to the missing information from those providers and enter them.

For the purpose of secondary analyses, we also obtained:

*Baseline Data Form*: A computerized data collection form was used to collect demographic data, self-reported race and ethnicity, income (by category) and experience with and access to computers and the World Wide Web.

*Health Literacy Questionnaire*: We accessed health literacy using the Health Literacy Assessment (NVS) developed by Weiss.[34]

*Computer Literacy assessment*: In prior work, we had developed a computer literacy form to help assess what experiences and capabilities were necessary for successful use of our Virtual Lifestyle Management (VLM) Program. We used the same form to assess these skills in this study.

*Patient Satisfaction Survey (CAHPS)*: We used the Consumer Assessment of Healthcare Providers and Systems (CAHPS) Clinician & Group Survey to assess patient satisfaction with care, including supplemental sections on After Hours Email, Health Improvement, Health Promotion and Education, and Shared Decision-Making.

*Health Utilization Form*: Because adherence to recommended preventive and therapeutic recommendations has the potential to improve care, we will assess (using time line follow-back) the number of hospitalizations and emergency room visits for each participant at 6-month intervals.

*PHR Feature Evaluation Form:* The assessment tool was developed by the UPMC ISD division for the specific purpose of evaluating the usefulness of various components of the PHR. It has been used by UPMC in its ongoing evaluation of the various components of the PHR. We adapted this form to create two versions of the form, one for passive PHR patients, which will contain additional items about facilitators and barriers to use, one for active PHR patients, which in addition will also contain items evaluating the 'active' features unique to the active PHR.

*Barriers to Self-management*: We used a 47-item assessment tool developed by Bayliss that assesses barriers to patient self-management across 11 domains.[35-37]

*PHR Utilization Data:* The PHR records data on patient utilization, including the number of log-ins, and the number of times each feature (e.g., appointment requests, HMFS, messaging, entering data into flow sheets) was used was obtained through electronic reports every 6 months.

***Intervention***: The intervention was a more active and interactive version of the HealthTrak personal health record application. Described in more detail in Fischer, et al, the application collects certain preventive health and disease management "gaps" based on age, gender, and disease-specific recommendations, and on a two-month cycle, sends electronic messages by email to the patient instructing him/her to log onto their Personal Health Record to read important health information.[38] Once in HealthTrak (the UPMC version of a Personal Health Record), the list of prevention and/or care "gaps" is presented, and (with some of them) a quick link can initiate the required action to close the gap. If the patient does not log into HealthTrak for a week after being sent the reminder, another reminder is sent, and if no logon occurs, a third email message as well as a letter is sent. After the third email, the reminder timer is reset to wait another two months and once again collect all unmet care gaps, and restart the process.

***Measures***: The main outcome measure for the study was the percent of prevention and treatment gaps that were closed from enrollment to final follow-up. Secondary outcome measures included rates of screening tests performed, levels of various disease and risk indicators (blood pressure, cholesterol, Hemoglobin A1C) and 10-year predicted cardiovascular risk. We also collected substantial data on potential confounders (literacy, income, computer use, etc.) to be able to assess the impact of these factors on the successful use of an electronic PHR. However, because the trial is randomized, we do not expect these confounders to affect our interpretation of the main effect of the intervention.

***Limitations***: There are several limitations to this work. First, although it was a design decision, our intervention is relatively weak: it consists of patient-directed alerts to check HealthTrak for important information, and if the patient responds, for some of the prevention and treatment gaps, allowed the patient to initiate the test or visit that would close that gap. Second, the intervention took place in an environment that is constantly working to improve prevention and treatment of chronic disease: during the time of our study, the UPMC Health Plan and Highmark (the two dominant insurers in the area) both increased the pay-for-performance incentives for physicians to have closed prevention and treatment gaps, providing incentives for adherence to these recommendations. In fact, in the control group, we found a much higher gap closure rate

that we had predicted based on data from these same practices in 2009, on which the power calculations for this study were created.

**Results** (Principal Findings, Outcomes, Discussion, Conclusions, Significance, Implications)

***Principal Findings***: **Specific Aim 2: Randomized Controlled Trail of Active PHR**

Enrollment for the trial was successful; we were able to recruit 1169 patients for randomization, which exceeded our initial sample size calculations which indicated a need for approximately 1000 patients. **Table 1** reports the enrollment data with some of the baseline characteristics. Figure 1 (page X) provides the Consort diagram for this trial. No characteristics were significantly different between intervention and control.

| Charateristic | Overall n(%) or mean (sd) [n=1169] | Control n(%) or mean (sd) [n=585] | Intervention n(%) or mean (sd) [n=584] | p-value |
|---|---|---|---|---|
| age | 58.3 (10.6) | 58.1 (10.7) | 58.5 (10.6) | 0.587 |
| gender: | | | | 0.427 |
| Male | 545 (46.6%) | 280 (47.9%) | 265 (45.4%) | |
| Female | 624 (53.4%) | 305 (52.1%) | 319 (54.6%) | |
| | | | | |
| Race | | | | |
| Black | 156 (13.3%) | 88 (15.1%) | 68 (11.5%) | 0.105 |
| White | 995 (84.9%) | 484 (82.9%) | 511 (86.9%) | 0.027 |
| Native Am | 7 (0.6%) | 2 (0.3%) | 5 (0.9%) | 0.180 |
| Asian | 14 (1.2%) | 10 (1.7%) | 4 (0.7%) | 0.252 |
| | | | | |
| Clinical | | | | |
| Diabetes | 428 | 128 | 111 | 0.754 |
| Systolic BP | 130 (14.8) | 129 (15.1) | 130 (14.5) | 0.481 |
| Diatolic BP | 78.8 (9.58) | 78.4 (9.62) | 79.3 (9.52) | 0.157 |
| Cholesterol | 175 (52.5) | 174 (53.0) | 176 (52.1) | 0.527 |

**Table 1.** Enrollment results

Primary outcome follow-up data came directly from the electronic health record, so we have virtually no loss to follow-up on the primary outcomes. For many of the secondary outcomes, which were based on follow-up survey analyses, we do have some missing data.

**Primary Outcome**: The intervention, an active and interactive version of the personal health record, did not improve prevention and treatment gap closure among patients with or at high risk for developing cardiovascular disease, compared to patients enrolled in the standard, passive version of the PHR. As can be seen in **Table 2**, none of the gap closure rates were significantly different in the intervention compared to the control group. Similarly, in **Table 3**, the intervention did not have an effect on physiological variables at 1 year, nor on the calculated 10-year cardiovascular risk score (**Table 4**).

One of the most likely reasons for the negative result is that we assumed a poorer level of compliance with preventive and treatment recommendations that we observed in the trial. We used estimates from the UPMC ambulatory quality reports from late 2009 (when the grant was written) to estimates our power calculations. The UPMC ambulatory practices have been engaged in multiple quality improvement projects regarding compliance to recommended care, and adherence has improved substantially, even in the absence of the RCT. For example, or original power calculation was based on a 62% rate of adherence to lipid recommendations (LDL <100 mg/dl if diabetes or heart disease, below 130 mg/dl if high risk), yet in our trial the overall rate for this was 81% (79.2% in controls, 83.0% in the intervention group) already a

greater improvement that we had expected to see with the intervention. For all of the other gap closures, we had seen a large improvement in UPMC ambulatory practices from the time we made the original power calculations.

To investigate whether this might have contributed to the negative trial, we stratified practices by their baseline adherence to prevention and treatment guidelines. Using data from the UPMC Physician Services Division that examined prevention and treatment gap data for the practices that had enrolled patients in our study, we created performance rankings for our practices, and divided those rankings into quartiles. Therefore, the assessment of the performance ranking is from data completely independent from the gap closure data collected in SMART. **Table 5** shows that for some medical services there was a statistically significant increase in gap closure rate in the intervention group.

**Secondary Outcomes**:

One of the important characteristics of alerts and reminders in general is "alert fatigue": too many alerts may push people to ignore important alerts. We examined the rate at which gaps were closed (in the intervention arm) as a function of the specific reminder cycle of the alert sent to the patient. (Patients were sent an email alert once a week until either 3 emails had been sent or the patient logged into HealthTrak.) **Figure 1** shows the gap closure rate by alert cycle, indicating that patients continue to respond and close gaps after multiple reminders: there is not significant alert fatigue. While only three cycles are shown in this figure, the results remain the same throughout the study.

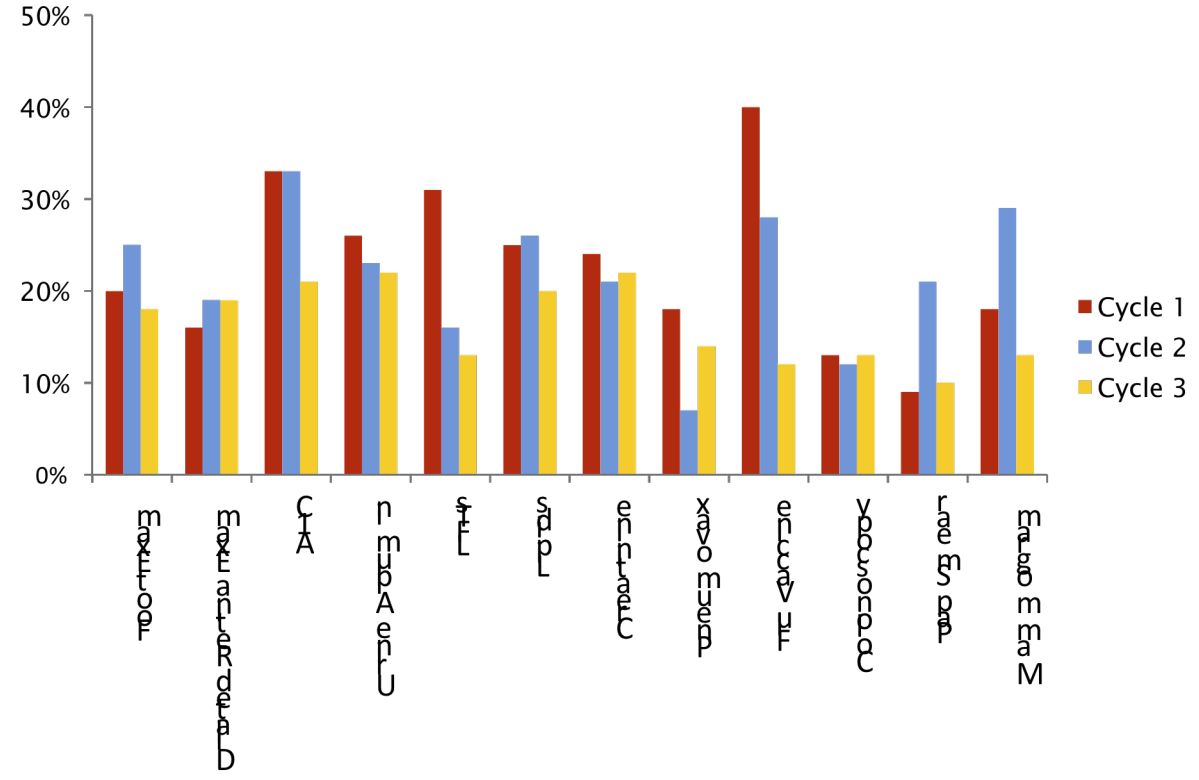



Figure 1. Gap closure rate by alert cycle

**Principle Findings**: **Specific Aim 3: Barriers and facilitators to implementation and use of an electronic PHR.**

Several themes arose from the focus group discussions. First, users found that the active portal increased their awareness of health care conditions and that they felt more proactive about using and keeping track of their health care information. Second, the active portal was a facilitator of patient-driven communication, and that features such as notification of test results and reminders of particular prevention needs was useful. Finally, interaction with the active portal improved many patients preparation for their face-to-face meeting with their provider, and allowed them to be more engaged in the discussion.

We continue to analyze the follow-up survey data: results of those analyses are not yet complete.

***Outcomes***: Outcomes are described within the results of each specific aim. One of the important characteristics of this trial is that for the primary outcome, we used the EHR itself to provide the data, and we had essential 100% follow-up for those outcomes.

In addition to outcomes calculated from EHR data (prevention and treatment gap closure rates, predicted 10 year cardiovascular risk) we are in the process of analyzing the relationship between outcomes and several survey-based reports of literacy, numeracy, experience with EHR, and many other patient-reported outcomes.

The primary outcomes for Aim 3 were reports and abstractions from focus groups. We have not yet analyzed all of the data from some of the follow-up questionnaires.

***Discussion***: In a randomized controlled trial, we find no significant difference in prevention and treatment gap closure rates between an active and interactive PHR and a standard, passive PHR. Although we demonstrated active engagement with the PHR, and that patients did not appear to tire of receiving alerts and reminders about their health, the overall effect on prevention and treatment services was minimal. We did find that the intervention improved prevention and treatment gap closure rates in patients who were seen in practices that were in the lower quartile of guideline adherence performance. We suspect that the negative trial in part was due to an a much higher rate of compliance to prevention and treatment recommendations that we had observed at the time the trial was initiated. These rates significantly improved for a host of reasons between the time the trial was started analysis occurred. We did find however that patients are interested in engaging in their healthcare through a personal health record, been through focus groups found that the presence of the more active and interactive PHR was considered a significant improvement in patients abilities to interact with their health and healthcare providers.

***Conclusions***: We conclude that the specific intervention of an active and interactive reminder system for prevention and treatment gaps in a large academic medical center did not significantly improve gap closure rates. We did however find that in practices for which gap closure rates were extremely poor the intervention did significantly improve rates of adherence to these clinical recommendations. Our results should serve as a caution against government policies encouraging or requiring the use of automatic electronic reminders to patients, given the lack of data that they are effective.

***Significance***: This randomized controlled trial adds to the evidence base for the effectiveness of using electronic health records in the improvement of care. Specifically this trial suggests caution is necessary in the use of personal health records to improve the quality of care.

***Implications***: As the presence of personal health records expands, care must be taken in the design and implementation of patient directed tools designed to improve care. Although engagement in the personal health record can be increased, engagement alone may not be sufficient to improve overall prevention care and treatment of chronic diseases.

| Table 2: Gap Closure | | | | |
|---|---|---|---|---|
| **Question / Description** | **Overall** n (%) or mean (sd) | **1-Control** n (%) or mean (sd) | **2-Intervention** n (%) or mean (sd) | p-value* |
| **Disease-Related Services** | | | | |
| **A1C** | **n=443** | **n=224** | **n=219** | 0.346 |
| Open | 115 (26.0%) | 63 (28.1%) | 52 (23.7%) | |
| Closed | 328 (74.0%) | 161 (71.9%) | 167 (76.3%) | |
| **LDL** | **n=840** | **n=428** | **n=412** | 0.187 |
| Open | 159 (18.9%) | 89 (20.8%) | 70 (17.0%) | |
| Closed | 681 (81.1%) | 339 (79.2%) | 342 (83.0%) | |
| **Creatinine** | **n=1017** | **n=503** | **n=514** | 0.614 |
| Open | 135 (13.3%) | 70 (13.9%) | 65 (12.6%) | |
| Closed | 882 (86.7%) | 433 (86.1%) | 449 (87.4%) | |
| **Potassium** | **n=857** | **n=428** | **n=429** | 0.846 |
| Open | 107 (12.5%) | 52 (12.1%) | 55 (12.8%) | |
| Closed | 750 (87.5%) | 376 (87.9%) | 374 (87.2%) | |
| **Eye** | **n=435** | **n=224** | **n=211** | 0.42 |
| Open | 176 (40.5%) | 86 (38.4%) | 90 (42.7%) | |
| Closed | 259 (59.5%) | 138 (61.6%) | 121 (57.3%) | |
| **Total Disease Related** | **n=1110** | **n=554** | **n=556** | |
| | 0.79 (0.35) | 0.78 (0.36) | 0.79 (0.34) | 0.675 |
| **Preventative Services** | | | | |
| **Pap Smear** | **n=372** | **n=180** | **n=192** | 0.804 |
| Open | 96 (25.8%) | 48 (26.7%) | 48 (25.0%) | |
| Closed | 276 (74.2%) | 132 (73.3%) | 144 (75.0%) | |
| **Mammogram** | **n=456** | **n=223** | **n=233** | 0.948 |
| Open | 68 (14.9%) | 34 (15.2%) | 34 (14.6%) | |
| Closed | 388 (85.1%) | 189 (84.8%) | 199 (85.4%) | |
| **Pneumovax** | **n=796** | **n=399** | **n=397** | 1 |
| Open | 438 (55.0%) | 220 (55.1%) | 218 (54.9%) | |
| Closed | 358 (45.0%) | 179 (44.9%) | 179 (45.1%) | |
| **Influenza** | **n=986** | **n=496** | **n=490** | 0.799 |
| Open | 187 (19.0%) | 92 (18.5%) | 95 (19.4%) | |
| Closed | 799 (81.0%) | 404 (81.5%) | 395 (80.6%) | |
| **Colonoscopy** | **n=880** | **n=434** | **n=446** | 0.416 |
| Open | 148 (16.8%) | 78 (18.0%) | 70 (15.7%) | |
| Closed | 732 (83.2%) | 356 (82.0%) | 376 (84.3%) | |
| **Total Preventative Services** | **n=1076** | **n=534** | **n=542** | |
| | 71% (29%) | 71% (29%) | 72% (29%) | 0.539 |

| Overall Services Total | n=1155 | n=578 | n=577 | |
|---|---|---|---|---|
| all_score | 74% (28%) | 73% (28%) | 74% (27%) | 0.617 |

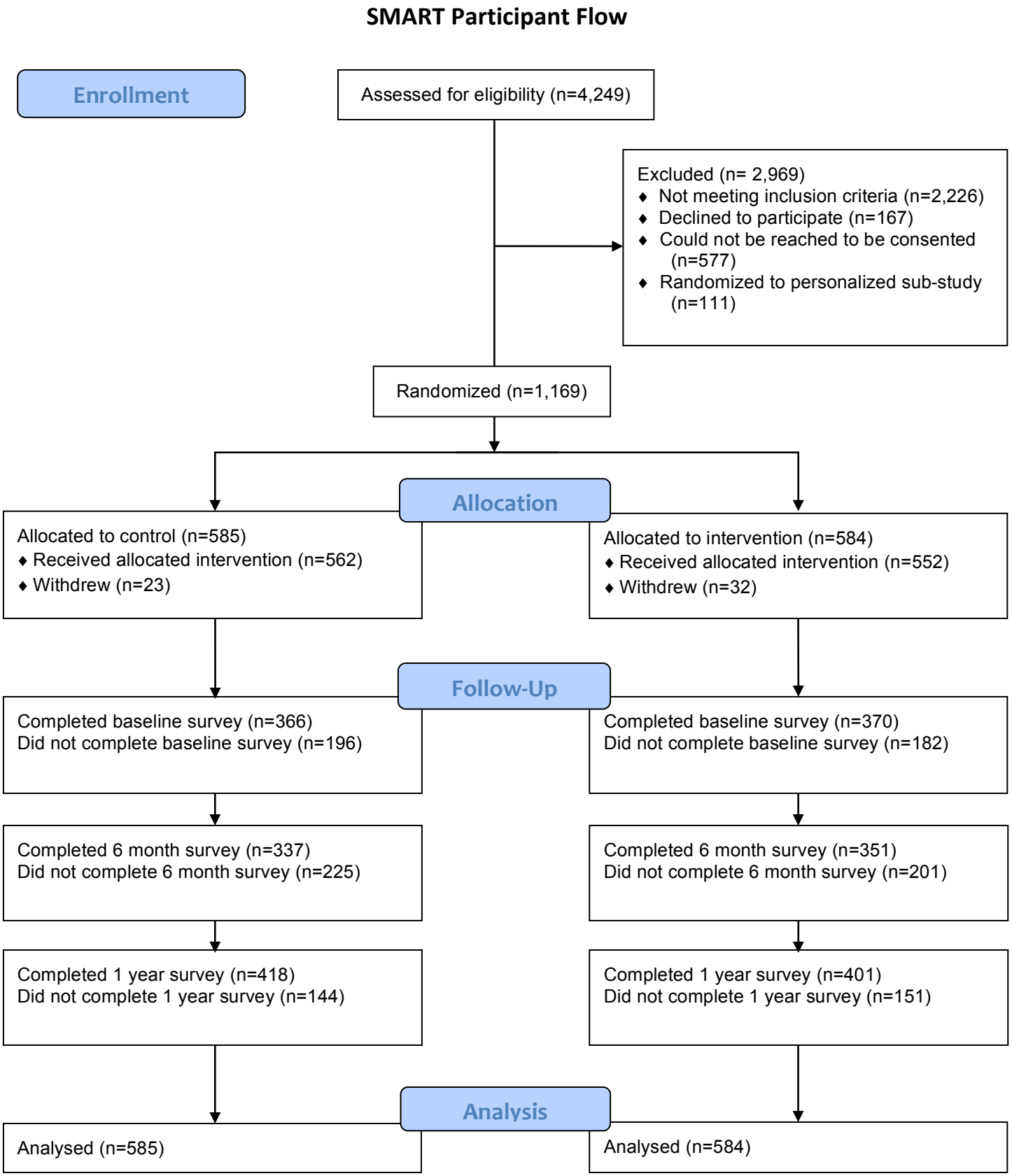
| Table 3: Physiologic Secondary Outcomes | | | | |
|---|---|---|---|---|
| **Outcome** | **Overall** mean (sd) | **1-Control** mean (sd) | **2-Intervention** mean (sd) | p-value* |
| | **n=1125** | **n=565** | **n=560** | |
| Total Cholesterol at Baseline | 175 (52.5) | 174 (53.0) | 176 (52.1) | 0.527 |
| HDL at Baseline | 49.1 (18.1) | 48.6 (18.5) | 49.6 (17.7) | 0.408 |
| LDL at Baseline | 99.9 (40.6) | 99.6 (40.4) | 100 (40.9) | 0.791 |
| Systolic BP at Baseline | 130 (14.8) | 129 (15.1) | 130 (14.5) | 0.481 |
| Diastolic BP at Baseline | 78.8 (9.58) | 78.4 (9.62) | 79.3 (9.52) | 0.157 |
| A1c at Baseline | 6.59 (1.30) | 6.57 (1.27) | 6.61 (1.33) | 0.663 |
| Total Cholesterol at 1 year | 169 (48.1) | 172 (49.2) | 166 (47.0) | 0.238 |
| HDL at 1 year | 48.3 (16.7) | 48.7 (18.4) | 48.0 (15.0) | 0.669 |
| LDL at 1 year | 94.8 (39.7) | 97.9 (40.1) | 91.8 (39.1) | 0.129 |
| Systolic BP at 1 year | 128 (15.0) | 128 (14.3) | 129 (15.6) | 0.339 |
| Diastolic BP at 1 year | 77.3 (9.29) | 77.2 (9.56) | 77.3 (9.01) | 0.939 |
| A1c at 1 year | 6.94 (1.40) | 6.94 (1.46) | 6.94 (1.33) | 0.994 |
| Difference in Total Cholesterol | -0.55 (48.4) | 0.58 (47.4) | -1.61 (49.4) | 0.664 |
| Difference in HDL | -0.39 (12.6) | -0.34 (12.2) | -0.43 (13.0) | 0.946 |
| Difference in LDL | -0.82 (39.1) | 0.83 (40.4) | -2.43 (37.9) | 0.417 |
| Difference in Systolic BP | -1.09 (17.2) | -1.56 (17.7) | -0.61 (16.7) | 0.418 |
| Difference in Diastolic BP | -1.30 (10.8) | -0.86 (10.9) | -1.75 (10.7) | 0.227 |
| Difference in A1c | 0.05 (1.08) | 0.08 (1.23) | 0.02 (0.93) | 0.644 |

| Table 4: Cardiovascular Risk Score | | | | |
|---|---|---|---|---|
| **CVD Risk Likelihood (over 10 years)** | **Overall** mean (sd) | **1-Control** mean (sd) | **2-Intervention** mean (sd) | p-value* |
| | **[n=1112]** | **[n=557]** | **[n=555]** | |
| Based on Total Cholesterol (TC) at Baseline | 0.11 (0.07) | 0.11 (0.07) | 0.11 (0.07) | 0.879 |
| Baseline Based on LDL at Baseline | 0.10 (0.07) | 0.10 (0.07) | 0.10 (0.07) | 0.677 |
| Based on TC at 1 Year | 0.11 (0.07) | 0.11 (0.07) | 0.11 (0.07) | 0.365 |
| Based on LDL at 1 Year | 0.11 (0.07) | 0.11 (0.07) | 0.11 (0.07) | 0.398 |
| Difference Between Baseline and 1 Yr Based on TC | 0.00 (0.06) | 0.00 (0.06) | 0.00 (0.06) | 0.788 |
| Difference Between Baseline and 1 Yr Based on LDL | 0.01 (0.06) | 0.01 (0.06) | 0.01 (0.06) | 0.96 |

Table 5: Selected outcomes by quartile of practice performance

| Outcome | 1-Control n (%) | 2-Intervention n (%) | Overall n (%) | p-value* |
|---|---|---|---|---|
| **Gap Closure of LDL Testing in Practices Ranked in the Lowest Quartile** | | | | |
| ***Open Count*** | **27** | **15** | **42** | 0.013 |
| Row Percentage | 64.29 | 35.71 | 100 | |
| Column Percentage | 27.55 | 13.64 | 20.19 | |
| ***Closed Count*** | **71** | **95** | **166** | |
| Row Percentage | 42.77 | 57.23 | 100 | |
| Column Percentage | 72.45 | 86.36 | 79.81 | |
| ***Total Count*** | **98** | **110** | **208** | |
| Row Percentage | 47.12 | 52.88 | 100 | |
| Column Percentage | 100 | 100 | 100 | |
| **Gap Closure of LDL Testing in Practices Falling Below the 25th Percentile** | | | | |
| ***Open Count*** | **29** | **18** | **47** | 0.017 |
| Row Percentage | 61.7 | 38.3 | 100 | |
| Column Percentage | 28.71 | 15.38 | 21.56 | |
| ***Closed Count*** | **72** | **99** | **171** | |
| Row Percentage | 42.11 | 57.89 | 100 | |
| Column Percentage | 71.29 | 84.62 | 78.44 | |
| ***Total Count*** | **101** | **117** | **218** | |
| Row Percentage | 46.33 | 53.67 | 100 | |
| Column Percentage | 100 | 100 | 100 | |
| **Gap Closure of Creatinine Testing in Practices Ranked in the Lowest Quartile** | | | | |
| ***Open Count*** | **22** | **11** | **33** | 0.016 |
| Row Percentage | 66.67 | 33.33 | 100 | |
| Column Percentage | 20.95 | 9.40 | 14.86 | |
| ***Closed Count*** | **83** | **106** | **189** | |
| Row Percentage | 43.92 | 56.08 | 100 | |
| Column Percentage | 79.05 | 90.60 | 85.14 | |
| ***Total Count*** | **105** | **117** | **222** | |
| Row Percentage | 47.3 | 52.70 | 100 | |
| Column Percentage | 100 | 100.00 | 100 | |
| **Gap Closure of Creatinine Testing in Practices Falling Below the 25th Percentile** | | | | |
| ***Open Count*** | **22** | **13** | **35** | 0.029 |
| Row Percentage | 62.86 | 37.14 | 100 | |
| Column Percentage | 20.56 | 10.32 | 15.02 | |
| ***Closed Count*** | **85** | **113** | **198** | |
| Row Percentage | 42.93 | 57.07 | 100 | |
| Column Percentage | 79.44 | 89.68 | 84.98 | |
| ***Total Count*** | **107** | **126** | **233** | |
| Row Percentage | 45.92 | 54.08 | 100 | |
| Column Percentage | 100 | 100 | 100 | |
| **Gap Closure of A1C Testing in Practices Ranked in the Lowest Quartile** | | | | |
| ***Open Count*** | **22** | **16** | **38** | 0.047 |
| Row Percentage | 57.89 | 42.11 | 100 | |
| Column Percentage | 37.93 | 21.92 | 29.01 | |
| ***Closed Count*** | **36** | **57** | **93** | |
| Row Percentage | 38.71 | 61.29 | 100 | |
| Column Percentage | 62.07 | 78.08 | 70.99 | |
| ***Total Count*** | **58** | **73** | **131** | |
| Row Percentage | 44.27 | 55.73 | 100 | |
| Column Percentage | 100 | 100 | 100 | |

Figure 1: Recruitment



## List of Publications and Products:

**Papers:**

1. Fischer GS, Hess R, Landeen BM, Weimer M, Zieth CR, Dong X, Clark S, Roberts MS. Electronic reminders to patients within an interactive patient health record. *Telemed J E Health*. 2013 June; 19(6):497-500. PMID: 23611639

2. Zieth CR, Chia LR, Roberts MS, Fischer GS, Clark S, Weimer M, Hess R. The Evolution, Use, and Effects of Integrated Personal Health Records: A Narrative Review – resubmitted to *JAMIA* 8/30/2013

3. Zickmund SL, Hamm M, Nikolajski C, Lesky D, Rief J, Fischer GS, Weimer M, Clark S, Zieth C, Hess R. Using Health Information Technology to Foster Engagement: Patients' Experience with an Active Patient Portal. – submitted to *Health Communication*

4. Hess R, Fischer GS, Dong X, Weimer M, Zeith C, Clark S, Roberts MS. Patterns of Response to Patient-Centered Decision Support Through a Personal Health Record. Revise and Resubmit: *Telemedicine and eHealth*

5. Hess R, Fischer GS, Weimer M, Zeith C, Clark S, Roberts MS. The effect of an active personal health record on lowering cardiovascular risk in an ambulatory population. *In preparation*

**Presentations:**

1. Hess R, Fischer GS, Roberts MS. START ME UP: Patient Activation with MyChart. Epic User Group Presentation. Verona, WI 9/12/2012

2. Hess R, Fischer G, Weimer M, Clark S, Zieth C, Dong X, Roberts MS. Intensity of Messaging Necessary to Encourage Patients to Access the PHR: Preliminary Results from the SMART- PHR Study. Society for General Internal Medicine. Orlando, FL, May 2012

3. Chia L, Parisi L, Hess R, Clark S, Fischer G, Weimer M, Zieth C, Roberts MS. Integrated Personal Health Records in Patients with Diabetes: Methods and Study samples. Poster Presentation Academy Health Annual Research Meeting June 2011

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**Appendix: ICD-9 codes for inclusion**

Disease Eligibility Data for SMART Proposal
Disease for defining complex patients will be based on the following ICD-9 Codes:

**A: CAD** - "410.00", "410.01", "410.02", "410.10", "410.11", "410.12", "410.20", "410.21", "410.22", "410.30", "410.31", "410.32", "410.40", "410.41", "410.42", "410.50", "410.51", "410.52", "410.60", "410.61", "410.62", "410.70", "410.71", "410.72", "410.80", "410.81", "410.82", "410.90", "410.91", "410.92", "411.0", "411.1", "411.81", "411.89", "412", "413.0", "413.1", "413.9", "414.00", "414.01", "414.02", "414.03", "414.04", "414.05", "414.06", "414.07", "414.8", "414.9", "V45.81", "V45.82"

**B: CHF** - "428.9", "428.43", "428.42", "428.41", "428.40", "428.33", "428.32", "428.31", "428.30", "428.23", "428.22", "428.21", "428.20", "428.1", "428.0", "404.93", "404.91", "404.13", "404.11", "404.03", "404.01", "402.91", "402.11", "402.01"

**C. Cerebrovascular disease** –435, 435.0, 435.1, 435.2, 435.3, 435.8, 435.9, 436, 437, 437.0, 437.8, 437.9, 438, 438.0-438.9, 438.10-12, 438.19, 438.20-22, 438.29, 438.30-32, 438.39, 438.40-42, 438.50-53,438.81-89,

**D. Other Vascular disease** – 440, 440.0, 440.1, 440.2, 440.20-24, 440.29, 440.3, 440.30-32, 440.8, 440.9

**E. Diabetes** – any code that starts with "250"

**F. HTN** – "401.0", "401.1", "401.9", "405.01", "405.09"

**G. Hyperlipidemia** – 272.0-272.9

Then we need to know, for each department:
Patient will be considered complex and at high risk for cardiovascular complication if:

Has any of **A, B, C, or D.**
Has at least 2 from **E, F, G**