

Contributors to frequent telehealth alerts including false alerts for patients with heart failure: A mixed methods exploration

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Keywords

Telehealth alerts, false alerts, heart failure, home health nursing

Summary

Background: Telehealth data overload through high alert generation is a significant barrier to sustained adoption of telehealth for managing HF patients.

Objective: To explore the factors contributing to frequent telehealth alerts including false alerts for Medicare heart failure (HF) patients admitted to a home health agency.

Materials and Methods: A mixed methods design that combined quantitative correlation analysis of patient characteristic data with number of telehealth alerts and qualitative analysis of telehealth and visiting nurses' notes on follow-up actions to patients' telehealth alerts was employed. All the quantitative and qualitative data was collected through retrospective review of electronic records of the home health agency.

Results: Subjects in the study had a mean age of 83 (SD = 7.6); 56% were female. Patient co-morbidities ($p < 0.05$) of renal disorders, anxiety, and cardiac arrhythmias emerged as predictors of telehealth alerts through quantitative analysis ($n = 168$) using multiple regression. Inappropriate telehealth measurement technique by patients (54%) and home healthcare system inefficiencies (37%) contributed to most telehealth false alerts in the purposive qualitative sub-sample ($n = 35$) of patients with high telehealth alerts.

Conclusion: Encouraging patient engagement with the telehealth process, fostering a collaborative approach among all the clinicians involved with the telehealth intervention, tailoring telehealth alert thresholds to patient characteristics along with establishing patient-centered telehealth outcome goals may allow meaningful generation of telehealth alerts. Reducing avoidable telehealth alerts could vastly improve the efficiency and sustainability of telehealth programs for HF management.

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1. Background and Significance

Heart failure (HF) is one of the most expensive chronic diseases among the elderly because of the high cost of HF management and high readmission rates [1, 2]. Telehealth has been advocated for HF management to avoid costly emergency department visits and frequent HF hospitalizations. However, the sustainability of telehealth programs has been problematic. Home health nurses have reported frustration with increased workload and lack of trust in efficacy of telehealth for managing HF [3–5]. Telehealth data overload including frequent telehealth alerts has been attributed as a significant barrier to sustained adoption of telehealth for managing HF patients [5, 6]. While telehealth alerts based on vital sign changes ought to provide guidance on the direction of care, frequent telehealth alerts that do not result in any follow-up intervention can result in “alert fatigue” [7] and reduce the efficacy of telehealth for managing HF. The proportion of total number of telehealth alerts associated with key medical events (events requiring medical or nursing attention) was found to be very low (2%) in a study on 45 patients with HF [8]. In our previous retrospective study conducted in a New England home health agency, 3% of overall telehealth alerts of 168 patients with HF were associated with key medical events of ER visits, hospitalizations, and medication changes. Additionally, no telehealth alert was generated for 22% of cardiac-related ER visits and hospitalizations [9]. These data suggested high frequency of telehealth alerts including redundant and false alerts. Not surprisingly, the authors of a review on home telehealth have suggested a need for research on malfunctioning telehealth equipment, patient or caregiver error, as well as missing or misinterpreted telehealth information [10] that could potentially contribute to high rates of false and avoidable telehealth alerts.

2. Objective

In the present study, we explored the factors contributing to the very high frequency of telehealth alerts found in our previous study [9], including false alerts (alerts that did not require any nursing or medical intervention). Potential solutions to reduce false and avoidable telehealth alerts are presented that could vastly improve the efficiency and sustainability of telehealth programs for HF management.

3. Telehealth process in the home health agency

In the home health agency studied, the telehealth system consisted of an electronic device in the patient’s home through which the patient transmitted his/her physiological data (e.g., weight, blood pressure [BP], heart rate [HR], and oxygen saturation [O₂ sat]) and answers to specific daily questions on his/her condition (e.g., “Have you experienced shortness of breath in the past 24 hours?”). During admission to the home health agency, the visiting nurse assessed the patients for eligibility for telehealth service based on existence of certain chronic conditions, availability of telephone landlines (POTS) and electricity, Medicare insurance, ability to ambulate safely to the telehealth device, cognitive ability if a caregiver was absent, and/or availability of the caregiver. After approval from the referring physician, the telehealth nurse utilized the patients’ home health admission vital signs to set the initial telehealth alert threshold. Telehealth alerts were generated when the vital signs were any value above or below the set threshold range. HF patients transmitted their telehealth data daily to the home health agency, which had been using telehealth services for over 10 years. The telehealth coordinator who was a nurse, managed the telehealth program and along with other telehealth nurses monitored the telehealth data for about 100 patients daily at the home health agency. Home health agency protocols required the telehealth nurse to address every telehealth alert and document the resulting follow-up action in the home health agency’s electronic health record (EHR). The telehealth nurse called the patient first to determine if any alert indicated a need for nursing or medical intervention. Alerts that required further intervention were communicated to the visiting nurse, who then contacted the patient and/or the referring physician or cardiologist to consult on patient

care. On the other hand, false alerts i.e. alerts that did not indicate any intervention, were documented electronically to indicate that the alert was addressed but no action was needed.

4. Methods

The EHR data on Medicare patients age 65 or above who were admitted to a home health agency with HF as a diagnosis and who used telehealth between March and September 2011, were retrospectively reviewed. A mixed methods design combining quantitative multivariate analysis of patient characteristic data from the home health EHR and qualitative analysis of telehealth logs and visiting nurses' electronic notes on follow-up actions to patients' telehealth alerts was employed. The quantitative data analysis was limited to the variables available in the Medicare-mandated home health data collection tool Outcomes and Assessment Information Set (OASIS - C) and medication management list. Qualitative exploration of the nurses' logs and notes revealed an additional layer of factors contributing to frequent telehealth alerts that could not be captured by the quantitative data analysis. Patients were excluded from the study if, during their entire telehealth service period, they transmitted telehealth data for less than 3 days or transmitted less than five vital sign parameters (weight, HR, systolic blood pressure (SBP), diastolic blood pressure (DBP), and O₂ sat). The study was approved by the Institutional Review Board of the academic institution with which the researchers are affiliated.

4.1 Home health electronic health record (EHR) data sources

The EHR database of the home health agency was queried using the ICD-9-CM codes 428.0, 428.2, 428.3, 428.43, 428.9, and 402 for eligible patients with a primary or secondary diagnosis of HF who had used telehealth services. Primary diagnosis is the main diagnosis for which a patient was admitted to the home health agency. Patients who used telehealth services were identified by querying the database for patients with telehealth vital signs and alerts data. The Medical Record Number of the patients, which is unique to the home health agency, was entered as the search criterion in the home health agency EHR to find corresponding study data for the patients. Study data included OASIS patient data as well as electronic nursing documentation notes and telehealth logs. Data for each patient were collected through an entire episode of telehealth (from admission to discharge) with the home healthcare agency.

The study investigators' prior research experience with home telehealth and characteristics commonly reported in the literature as associated with HF exacerbation or disease severity guided the choice of study variables [3, 11–14]. Data on patient demographics (age, race, and gender); psychosocial status (anxiety, depression, and living situation assessed by presence or absence of caregivers); disease characteristics (dyspnea, type [primary/secondary] of admitting HF diagnosis); number and types of co-morbidities; number of medications; type of cardiac medications; and status of HF diagnosis (new/chronic) were obtained from OASIS and nursing documentation notes. Telehealth alert characteristic data (type of telehealth vital sign alert: weight, SBP, DBP, HR, O₂ sat) were identified from the telehealth logs. Telehealth questionnaire data on symptoms experienced by patients (e.g., did you experience shortness of breath in the past 24 hours, how many pillows did you use while sleeping, etc.) were not available consistently for all subjects in this study and hence could not be collected.

The electronic nursing notes provided documentation on home health nursing interventions in response to the telehealth alerts, including teaching the patient on HF self-management or correct use of telehealth equipment, consulting the referring physician on medication changes, arranging patient visits to the office of referring physicians, or transferring patients to the hospital. For the qualitative analysis, patients who generated telehealth alerts were identified by purposive sampling. For the patients in the qualitative subsample, nursing notes and telehealth logs from the days with telehealth alerts were reviewed manually in the electronic documentation system to identify follow-up responses to telehealth alerts. Qualitative data were collected for 21% of the total study sample (n = 35) until redundancy in study findings was attained.

4.2 Data analysis

Descriptive statistics were calculated for all patient characteristics and telehealth alert data. Before the data were analyzed, variables were examined to assess for missing data, errors in data entry, and identification of outliers. The means, standard deviations, and percentiles for all continuous variables as well as frequency distributions for all discrete variables and missing values, if any, were obtained.

Stepwise multiple regression analysis was used to analyze the impact of independent variables on the continuous outcome variable of total number of telehealth alerts. Total number of telehealth alerts per subject was calculated and normalized to obtain a standardized representation of number of telehealth alerts over the duration of telehealth service (length of stay, LOS). Normalization was achieved by dividing the number of telehealth alerts by the telehealth LOS. For example, a patient who triggered 20 alerts in a telehealth LOS of 10 days had 200% ($20/10 * 100$) of telehealth LOS with telehealth alerts, whereas a patient who triggered 10 alerts over 20 days had 50% ($10/20 * 100$) of telehealth LOS with telehealth alerts. Univariate analysis was used to eliminate variables showing associations with the outcome variable at a significance level >0.25 [15]. Then all variables at $p \leq 0.25$ were examined for inclusion in the initial multivariate model. Variables were eliminated in an iterative fashion by the stepwise multiple regression analysis until the final multiple regression model included variables with associations at $p < 0.05$ for the overall model. Suspected effect modifiers and confounders (covariates without significance in prior steps) were not found significant using partial F-tests, and therefore were not included in the final model.

Telehealth logs and visiting nurses' notes in response to telehealth alerts were qualitatively analyzed and coded using the constant comparative method until saturation was attained. Codes within similar contexts of telehealth alert generation were grouped together to form themes. The primary investigator (KR) first performed the content analysis. Then the telehealth coordinator (AZS) completed independent member checks on 50% of the qualitative sample that addressed all the identified themes to ensure the validity and reliability of the qualitative data analysis. The reliability of the coded classification was then affirmed by having the co-investigator (KB) code the same 50% of the sample, discuss disagreements, and reach consensus.

5. Results

The study dataset included data on 168 Medicare HF patients with a mean age of 83 (SD = 7.6); 96% were Caucasians and 56% females. HF was a primary admitting diagnosis in 54% of the patients. Presence of dyspnea as reported in OASIS was observed in 86% of the patients. The average number of co-morbidities was 5.5, with vascular disorders (70%), hypertension (64%), and musculoskeletal disorders (50%) being the most common co-morbidities (► Table 1). Patients received telehealth service ranging from 1 to 25 weeks, with a mean duration of 7 weeks. During the 6-month study period, a total of 6,025 telehealth alerts related to the physiological vital signs of weight, SBP, DBP, HR, and O₂ sat were generated, with an average of 36 alerts per subject. The mean (SD) of normalized telehealth alerts was 84.4 (48.5) (► Table 1). Association between duration of telehealth service and normalized alert rates was found to be non-significant ($p = 0.44$).

For the qualitative analysis, 172 visiting nurses' notes and 1,208 telehealth nurses' logs of 35 patients were explored to identify contributors to frequent telehealth alerts including false alerts. The subsample of 35 patients closely represented the characteristics of the larger sample (► Table 1). However, the average number of telehealth alerts generated was higher in the qualitative subsample (53.6) than in the overall study sample (35.9).

5.1 Contributors of frequent telehealth alerts including false alerts

Ideally only physiological or symptomatic changes related to the HF disease process should trigger telehealth alerts. However, this mixed method analysis showed that certain patient co-morbidities, inaccurate telehealth measurements, or home healthcare system inefficiencies played a significant

role in triggering frequent telehealth alerts. The following sections present the contributors of frequent telehealth alerts including false alerts.

5.1.1 Patient characteristics: Co-morbidities

In both quantitative and qualitative analysis, co-morbidity characteristics of patients played a significant role in the generation of telehealth alerts. In the final multiple regression model, co-morbidities of anxiety ($p = 0.03$), cardiac arrhythmia ($p = 0.04$), and renal disorders ($p = 0.02$) had statistically significant positive associations with frequent telehealth alert generation (► Table 2). Patients with arrhythmia, renal disorders, and anxiety were consistently found to generate frequent telehealth alerts in the qualitative analysis also:

- Telehealth nurse note 1: Weight gain consistent with patient's M-W-F dialysis schedule
 - (now 3 days since dialysis)
- Telehealth nurse note 2: Results sometime vary widely (see today's HRs of 53 and 131)
 - due to A. fib (Atrial fibrillation)

For the majority of HF patients with renal disorders and arrhythmia, telehealth service was soon discontinued because the high rate of telehealth alerts generated did not result in meaningful changes to patients' care plans.

5.1.2 Patient characteristics: HF self-management behaviors

Patients who smoked, ate salty food, were non-adherent with their HF medication regimen, or were otherwise not engaged with HF self-management behaviors also generated frequent telehealth alerts:

- Telehealth nurse note: Wife stated patient may have forgotten some meds last evening

These telehealth alerts were beneficial, because they provided home health nurses with the opportunity to reinforce patients' HF self-management behaviors, including medication adherence, in a contextually relevant manner. However, if the HF patients failed to engage with HF self-management behaviors after repeated attempts at teaching them, they were often discharged from the telehealth and/or the nursing service.

5.1.3 Inaccurate telehealth results due to inappropriate measurement technique

Inappropriate measurement technique of patients while using telehealth contributed to frequent telehealth alerts. Of the nurses' notes on 35 patients, 19 (54%) patients had inappropriate measurement technique cited as a contributor of telehealth false alerts. The telehealth weight alert was triggered when there was more than a 2-pound difference in a day or more than a 5-pound difference in a week. Despite instructions to restrict the use and transmission of telehealth data to the patient only, family members sometimes weighed themselves and transmitted their data through telehealth, resulting in a wide difference in weight from the set threshold for the week. So even if the family member weighed him-/herself on only one day, the weight telehealth alert was needlessly generated for the next 8 days until the weight difference was less than 5 pounds from the patient's weight at the beginning of that week.

Home health nurses frequently provided instructions to patients on weighing themselves, wearing similar clothes every day, adjusting the blood pressure cuff size correctly to their arms, or avoiding the use of telehealth devices immediately after physical exertion. The telehealth vital sign threshold ranges were set to the resting vital signs of the patients, so any deviation in activity would raise or lower the telehealth vitals above or below the set thresholds, generating telehealth alerts. Patients suffering from gait issues would sometimes lean during telehealth weight measurements, which would confound the weight value and generate alerts. Patients with HF and early dementia who did not have any caregiver to help them with telehealth measurement also triggered telehealth alerts through incorrect measurement techniques. Some patients measured themselves on telehealth before medication administration, which triggered telehealth alerts due to unadjusted vital signs pre-medication. However, such alerts can be considered a benefit of telehealth because patients could be

reminded to take their medications, as well as provide information on patient health status before medication administration.

5.1.4 Home healthcare system inefficiencies: Threshold revision

Telehealth alert threshold ranges for HF patients were based on the individual patients' home health admission vital signs post discharge from the hospital. However, after a few days, vital signs stabilized at a level different from the set alert thresholds, which triggered telehealth alerts daily for such patients. Only with physician approval could the telehealth thresholds be revised to the now stabilized vital signs. Slow responses of visiting home health nurses and physicians delayed the telehealth nurses' attempts to revise the alert thresholds:

- Telehealth nurse note: Patient's weight consistently under existing threshold... patient has
 - usual very low BP (see multiple prior notes re: low BP). 2nd request for threshold
 - revisions left

The visiting nurses and physicians did not consider revising telehealth thresholds to be a priority in patient care, because the patient was not experiencing any health crisis. Therefore the high rate of unnecessary telehealth alerts continued.

5.1.5 Home healthcare system inefficiencies: Unclear patient goals and expectations / Delays in clinical management

Persistent abnormal telehealth BP or weight vital sign alerts brought to the attention of the referring physician did not always result in changes to the medication or treatment regimen. Physicians and visiting nurses may wait for the patient to adapt physiologically to interventions such as medication changes before responding to the frequent telehealth alerts. Frequent telehealth alerts may also cause "alert fatigue" and potential disengagement from telehealth data, further contributing to the lack of clinician response to telehealth alerts. In addition, lack of communication between physicians and home healthcare providers regarding expectations about patient outcomes was evident. Telehealth nurses felt especially frustrated because their prompt attention to abnormal telehealth vital signs became inconsequential due to lack of follow-up interventions or communication by other healthcare providers. This frustration is obvious in the following quote from a telehealth nurse:

- Review of RN (registered nurse) visit note indicates that MD (physician) office was contacted re: BPs and weight gain and other vital signs but no med changes were made. Voice Mail left for RN with today's BP and weight data and requesting any feedback available as to how to respond to the frequent alerts that occur with this patient.

Of the nurses' notes on 35 patients, communication inefficiency in the home healthcare system was attributed to frequent telehealth alerts in 13 (37%) patients. Also, by the time the circle of communication was complete between the telehealth nurse, the patient, the visiting nurse, and the physician office, the patient had already experienced potentially preventable hospitalization and a high rate of telehealth alerts had been generated without any fix introduced to address those alerts. A sub-analysis of our study data found that among the HF patients who had their medications titrated by the physicians ($n = 37$), 73% did not experience cardiac hospitalization, although this association was not significant ($p = 0.16$).

6. Discussion

Co-morbidities related to renal disorders and cardiac arrhythmia have consistently played an adverse role in the outcomes of patients with heart failure [13, 19, 20]. The telehealth device was unable to accurately capture HR or O₂ sat of patients with cardiac arrhythmia co-morbidities, which triggered repeated telehealth alerts. Patients with renal failure on dialysis experienced weight fluctuations that triggered frequent telehealth alerts. For such patients, telehealth thresholds may need to be set differently, or perhaps these patients may not be good candidates for telehealth.

Anxiety also has consistently emerged as a predictor of high healthcare utilization for patients with HF using telehealth [3, 9, 21]. Anxiety needs to be identified and treated in HF patients, be-

cause it is a barrier to HF self-management [22]. Patients experience acute anxiety on seeing their vital signs fluctuate, which raises their vital signs above set threshold triggering more telehealth alerts without any meaningful changes to their care plan [3].

Potential solutions for managing telehealth alerts include non-generic telehealth alert thresholds tailored to a patient's contextual information, including presence of co-morbidities, psychosocial status, symptom status, and involvement with HF self-management [11]. Telehealth alert thresholds tailored to patient characteristics could allow the telehealth nurse to purposefully manage patient monitoring rather than address redundant alerts [23]. In addition, home health nurses should have the knowledge and flexibility to initiate interventions for other health issues based on the information obtained from the telehealth alerts. For instance, when false telehealth alerts are triggered by the leaning of an HF patient suffering from gait problems or pain, the home health nurse should be allowed the flexibility to improve the patient's gait by initiating interventions such as physical therapy or pain management. Such interventions could potentially eliminate the root of the problem triggering avoidable telehealth alerts.

Patient engagement with the telehealth process has been recognized as a factor influencing the effectiveness of telehealth in few other studies [3, 5, 16, 17]. In those studies, patients failed to engage with the telehealth process by dropping out of the telehealth programs or through failure to transmit telehealth data regularly. In the present study, patients with HF often displayed inadequate understanding of the telehealth process through incorrect telehealth measurement techniques. Home health nurses could encourage patient engagement with telehealth by providing periodic instruction on HF self-management and telehealth use, and emphasizing on physiological responses and patient behaviors that generate telehealth alerts. Patients could thus be empowered to utilize telehealth data to modify their HF self-care and monitoring behaviors [18]. Additionally, home health nurses should establish a telehealth routine compatible with patients' physical, environmental, and social contexts.

Long feedback loop between patients and multiple healthcare providers delay communication in response to frequent telehealth alerts, which in turn impair effectiveness of telehealth interventions [7]. Physicians and home healthcare providers, in conjunction with patients, could establish goals and expectations about outcomes tailored to patients' context, which might eliminate the need to communicate about every telehealth alert. Establishing such patient-centered goals would include care coordination protocols on timely changes to HF treatment regimen in response to abnormal telehealth vital signs as well as prompt revision of telehealth alert thresholds in response to newly stabilized vital signs. Home health agencies could also hire advanced practice nurses who would have the autonomy to initiate interventions such as diuretic medication titration, allowing a prompt response to true telehealth alerts. Utilizing telehealth alerts tailored to patients' contextual information along with improved care coordination and patient engagement is necessary to justify the use of telehealth for efficient HF management.

6.1 Limitations

The qualitative component in this study analyzed only the home health nurses' notes on contributors to frequent telehealth alerts. Patients and physicians might have unique perspectives on potential contributors to frequent telehealth alerts. The generalizability of the study findings may also be limited because the study data were restricted to one home health agency.

Associations of some co-morbidity variables with the number of telehealth alerts may need to be interpreted cautiously due to wide confidence intervals, because a small number of data end-points were available for analysis. However, this study is exploratory in nature, and it provides preliminary associations between characteristics of HF patients using telehealth and the number of telehealth alerts, which can be tested more rigorously in future studies with a larger sample.

7. Conclusion

In conclusion, this article urges a need for a paradigm shift in utilizing home telehealth programs for HF management. Encouraging patient engagement with the telehealth process, fostering a collabor-

ative approach among all the clinicians involved with the telehealth intervention, and tailoring telehealth alert thresholds to patient characteristics along with establishing patient-centered telehealth outcome goals may allow meaningful generation of telehealth alerts. Future research should evaluate the impact of appropriate and relevant telehealth alert generation on sustainability of telehealth programs as well as effectiveness of telehealth to attain optimal HF outcomes and home health resource utilization.

Clinical Relevance Statement

1. The contributors to frequent telehealth alerts including false alerts comprise of certain patient comorbidities, inappropriate telehealth measurement techniques by patients, and home healthcare system inefficiencies.
2. Encouraging patient engagement with the telehealth process, fostering a collaborative approach among all the clinicians involved with the telehealth intervention, tailoring telehealth alert thresholds to patient characteristics along with establishing patient-centered telehealth outcome goals may allow meaningful generation of telehealth alerts.
3. There is a need for research to evaluate the impact of meaningful telehealth alert generation on efficiency and sustainability of home telehealth interventions for heart failure management.

Conflicts of Interest

The first and the second author, Drs. Radhakrishnan and Bowles, do not report any conflict of interest in conducting this study. The third author, Ms. Zettek-Sumner, RN MS, is an employee at the home health agency where this study was conducted.

Protection of Human and Animal Subjects

The study was performed in compliance with the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects, and was reviewed by the University of Pennsylvania Institutional Review Board.

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Table 1 Descriptive Information on study sample

	Total sample (n = 168)	Qualitative sub-sample (n = 35)
	n (%)	n (%)
Demographics		
Age Mean (SD)	82.75 (7.6)	82.75 (8.3)
Race		
• African American	3 (1.8)	1 (2.9)
• Hispanic or Latino	4 (2.4)	1 (2.9)
• White	161 (95.8)	33 (94.3)
Gender		
• Males	74 (44.0)	17 (48.6)
• Females	94 (56.0)	18 (51.4)
HF Disease Characteristics		
HF as <u>Primary</u> Admitting Diagnosis	91 (54)	23 (65.7)
Status of HF Diagnosis		
• Newly Diagnosed	23 (13.7)	1 (2.9)
• Chronic HF	141 (83.4)	33 (94.3)
• Unknown	4 (2.4)	1 (2.9)
Dyspnea (at admission)		
• 0 – Never	24 (14)	5 (14.3)
• 1 – Climbing stairs	57 (33.9)	11 (31.4)
• 2 – With dressing, bathing	60 (35.7)	13 (37.1)
• 3 – With eating, conversation	23 (13.7)	5 (14.3)
• 4 – At rest	4 (2.4)	1 (2.9)
Total # of types of co-morbidities Mean (SD)	5.52 (1.9)	5.3 (1.8)
Types of Co-morbidities		
• Myocardial Infarction	26 (15.5)	5 (14.3)
• Cardiac Arrhythmia	71 (47.0)	20 (57.1)
• Valvular Disorders	12 (7.1)	3 (8.6)
• Pulmonary Disorders	70 (40.5)	18 (51.4)
• Vascular Disorders	122 (70.6)	26 (74.3)
• Hypertension	107 (63.7)	19 (54.3)
• Neurological Disorders	21 (12.5)	7 (20.0)
• Diabetes Mellitus	45 (26.8)	7 (20.0)
• Thyroid Disorders	39 (23.2)	10 (28.6)
• Renal Disorders	52 (31.0)	14 (40.0)
• Gastro-intestinal Disorders	25 (14.9)	5 (14.3)
• Cancer	14 (8.3)	5 (14.3)
• Musculo-skeletal disorders	85 (50.6)	14 (40.0)
• Dementia	19 (11.3)	6 (17.1)
• Psychiatric disorders	42 (25)	7 (20.0)
• Anxiety co-morbidity	15 (8.9)	3 (8.6)
• Anemia	24 (14.3)	4 (11.4)
• Obesity	40 (23.8)	7 (20.0)
Total # of Medications Mean (SD)	12.9 (4.6)	12.9 (4.1)
Psychosocial Characteristics		
Living Alone	46 (27.4)	10 (28.6)
Depression	27 (16.1)	5 (14.3)
Telehealth Alert Characteristics		
Total # Telehealth Alerts	6,025	1,860
Telehealth Alerts generated per subject Mean (SD)	35.9 (30.8)	53.1 (39.1)
Normalized Telehealth alerts per subject Mean (SD)	84.4 (48.5)	108.2 (44.1)

Table 2 Association of co-morbidity variables with number of telehealth alerts

Model	B	Std. Error	Standardized β	<i>p</i> value
Constant	69.06	5.88		
Anxiety	28.34	12.79	0.17	0.03
Cardiac Arrhythmia	15.05	7.34	0.16	0.04
Renal Disorders	18.55	7.91	0.18	0.02

$R^2 = 0.08$, Adjusted $R^2 = 0.06$, $F(3, 164) = 4.522$, $p = 0.004$

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