WaterMeter: an App for Monitoring Fluid Intake in Hemodialysis Patients

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Chronic Kidney Disease (CKD)

- A condition in which the kidneys are damaged and cannot filter blood as well as possible (CDC, 2011).
- Usually an irreversible and progressive disease and can lead to kidney failure/End Stage Renal Disease (ESRD) if it is not treated (CDC, 2011)
- The only treatment options for kidney failure are dialysis or a kidney transplant (CDC, 2011)
- Leading causes of ESRD:
  - Diabetes
  - Hypertension
- Less common causes of ESRD:
  - Glomerulonephritis
  - Hereditary kidney disease
  - Malignancies such as myeloma (CDC, 2011).
Prevalence/significance

DIALYSIS

• Currently, more than 480,000 U.S. citizens require renal replacement therapy (RRT)
• With 314,000 on hemodialysis.
• More than 25,000 receiving peritoneal dialysis
• Another 143,000 having received kidney transplants.

CKD

• Approximately 17 percent of the U.S. population has chronic kidney disease (CKD).
• Care of patients with some form of reduced kidney function constitutes fully 25 percent of the Medicare budget.
Economic Burden of Hemodialysis

- The United States has one of the highest incidence rates of ESRD in the world and the highest annual expenditure per ESRD patient, yet outcomes of dialysis care are relatively poor compared with other countries (Knauf & Aronson, 2009).
- Medicare reimburses most of the total cost of ESRD treatment in the United States (CDC, 2007)
- Currently, more than 360,000 people in the United States are undergoing dialysis, according to the US Renal Data Service McReady, (2009).
- Medicare spends approximately $73,000 annually per dialysis patient (McReady, 2009).
Rising cost of ESRD care in the United Stated is largely attributable to the growth of the prevalent ESRD population.

(A) ESRD spending by payor (Knauf & Aronson, 2009).

(B) Projected growth of prevalent dialysis and transplant populations in the United States (Knauf & Aronson, 2009).
Patient Burden

- CKD can be associated with:
  - Fluid overload
  - Sodium and potassium imbalances
  - Bone and mineral disorders
  - Anemia
  - Reduced quality of life (CDC, 2007)

ESRD IMPLICATIONS:
- ESRD is a costly and disabling condition associated with a high mortality rate (CDC, 2007)
Among patients aged 65 and older who were receiving dialysis, overall mortality rates in 2994 were seven times greater than among persons in the general Medicare population (CDC, 2007).

Premature death from both cardiovascular disease and from all causes is higher in adults with CKD compared to adults without CKD. In fact, individuals with CKD are 16 to 40 times more likely to die than reach ESRD (CDC< 2011).

Volume overload predisposes this already compromised group to cardiovascular events with poor outcome.
Purpose of WaterMeter

• Clinical experience and published data demonstrate that interventions aimed at reducing patients' interdialytic fluid intake are often ineffective (Flythe, Kimmel, & Brunelli, 2011) and this raises the need for a new approach that can increase patients’ compliance to interdialytic fluid and sodium restriction.

• Adequate interdialytic fluid control is critical for achieving patient’s dry weight with dialysis and avoiding higher ultrafiltration rates (UFRs).

• Study shows that higher (UFRs) are associated with greater Cardiovascular mortality (Flythe, Kimmel, & Brunelli, 2011).

• During dialysis, fluid is removed directly from the vascular space; when dialytic removal outpaces resorption from other compartments, circulating volume is reduced and transient myocardial ischemia can result (Flythe, Kimmel, & Brunelli, 2011).

• One important way to minimize UFR in current clinical practice is by limiting patients' fluid intake and/or by allowing more time for fluid removal i.e., extend dialysis time (Flythe, Kimmel, & Brunelli, 2011).

• The purpose of the Water Meter Application is to provide dialysis patients with a user-friendly method of controlling interdialytic fluid and sodium intake to recommended quantities.
Fluid Requirement

- Fluid Allowed: Determined by the Nephrologists.
- Considers residual kidney function—urine or no urine output.
- 1000-1500ml (33-50ounces). Weekday, between treatments.
- Friday-Monday 3000-4500 (Weekend).
Fluid Restriction

- The most difficult part of diet restrictions to follow because they are frequently thirsty.
- Have to remember that anything that turns to liquid at room temperature needs to be counted as fluid---usually very difficult to do.
- Fruits and ice constitutes biggest source of fluid intake.
- Patients find it difficult to quantify fluid intake from food.
- Salt intake contributes to fluid retention.
Available programs

- The American Association of Kidney Patients' "Na-K-Phos Counter."
- The National Kidney Foundation (NKF) produces "Dining Out With Confidence: A Guide for Renal Patients"
- Fluid Journals
- No apps currently available
Implications of Excess Fluid Removal

- Muscle cramping during dialysis – when attempt to remove excess fluid is made.
- Excess fluid removal can also cause a drop in blood pressure, loss of consciousness.
- Feeling nauseated, dizzy and weak after the treatment.
- Sometimes, an extra dialysis session may be required to remove all the extra fluid.
- Hospitalization
- Dialysis access problems
Implications of Excess Fluid Intake

- High blood pressure
- A sudden drop to low blood pressure (generally occurs during hemodialysis)
- Shortness of breath (and in some instances, fluid in the lungs)
- Heart problems, which can include a fast pulse, weakened heart muscles and an enlarged heart
- Hospitalization
- Congestive Heart failure
- Pulmonary Edema
Measurement of Fluid Nonadherence

- Weight gain between 2 hemodialysis sessions, called interdialytic weight gain (IWG).
- Weight loss during a session, called intradialytic weight loss (IWL).
- Nonadherence with fluid restrictions results in excess weight gain between 2 dialysis sessions (IWG), which is lost again during a dialysis session (IWL).
- Indirect measurement of nonadherence to fluid restriction is also possible by self-report.
Water Meter: Intended platforms

- Android phone and tablet, iPhone, iPad
- Corona SDK can program both platforms
- Windows Mobile: future
- Blackberry: No
  - (RIM) most difficult source code to program (McHaney, 2011)
  - Blackberry has been losing market share
  - Only 17% of BB users download apps
    • (IDC, 2011)

WaterMeter

- Program is set with target (1-1.5 lt H2O, 1-1.2 gm. Na+)
- Pt enter beverages and foods to program which then records and tracks water and Na+ consumption
- Pt see a visual tracker of target
- Pt enter weight daily
Visual Tracker

- At >75% of target-graphic will be green
- 75-99% yellow
- 100% or greater red
WaterMeter

- Providers can join
- Search for pts
- Get permission to “follow”
- Providers can review pts data
- Tailor pt education
- Make adjustments to treatment plan
Initiation

• Mission statement: To develop a CDSS for the patient and provider to aid in preventing complications from fluid volume overload in ESRD patient.

• Project time to completion 8 weeks.
Initiation

Project Team
• F. Chidolue, U. Okani, M. Drew,
• Technical Team: Application Programmer, Graphic Designer, Faculty Supervision

Dr. Brian Burton Ed.D.
Mobile Programming Students Abilene Christian University- ACU Apps
Planning

• Work breakdown structure:
  – Acquiring nutritional information of popular foods
  – Measuring water volume of common fruits/foods
  – Sketching mock up of screens
Planning - WBS cont.

- Determine software requirements (Corona SDK)
- Design application
- Program graphics
- Merge programming
- Register copyright with Copyright office
Planning - Budget

- ACU Apps students stipend $2000
- Corona SDK licensing fee $50/year (educational rate)
- Apple licensing fee $99/year
- Google licensing fee $35/lifetime
- Copyright fee $35
- Mileage, meals $300
- Total $2520
Execution

• Trial product with an audience
• Get feedback
• Correct bugs, errors in code changes based on trial feedback
• Submit Copyright applications
• Submit final products to Apple, Android/Google
• Launch in Apps Stores
• Market to National Kidney Foundation, Dialysis Centers, American Nephrology Nurse Assn.
Evaluation

- Get feedback from trial audience and make changes based on critique
- Track numbers of downloads
- Ask users to rate the product and make suggestions for improvement
- Provide regular updates
- Evaluate data to determine if fluid management improves over time
Outcomes Measurements

- **Achievement of Optimal “Dry” Weight** - defined as the weight when fluid volume is optimal; also is the lowest weight tolerable to patient without development of hypotensive symptoms.

- **Level of blood pressure**: Hypertension may be a sign of hypervolemia (fluid overload).

- **Evidence of fluid overload** (BP and weight gain).

- **Patient's tolerance of ultrafiltration**.

- **Interdialytic weight gain** (should not exceed 1 kg during the week and 1.5 to 2 kg during the weekend).
Potential Sources of Funding

- Stakeholders such as:
  - Fresenius Medical Care
  - Davita
  - Renal care Group
  - Independent Dialysis Unit Operators
  - National Kidney Foundation
  - Gambro Health Care
  - Renal Advantage
References


References contd.