

Last updated: June 11, 2020

## OVERVIEW

The Teladoc Health clinical research team and data scientists are continually evaluating the effectiveness of our programs and features related to clinical and financial outcomes. This document provides a summary of the studies by condition (diabetes, mental health, diabetes prevention and hypertension) that have been published in peer-reviewed journals or presented at professional society conferences.

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Bollyky, Jennifer B., Stephanie T. Melton, Tong Xu, Stefanie L. Painter, and Brian Knox. 2019. **“The Effect of a Cellular-Enabled Glucose Meter on Glucose Control for Patients With Diabetes: Prospective Pre-Post Study.”** *Journal of Medical Internet Research*, 2019, vol. 4, no. 4: Oct-Dec. <https://doi.org/10.2196/14799>

**Objective:** To examine health outcomes measured by changes in A1c, time in target blood glucose range and depression symptoms for patients enrolled in a remote digital diabetes management program in a diabetes center of excellence setting.

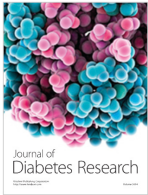
- Prospective, one-arm study N=86.
- Program was associated with:
  - A 17% decrease of BG checks <70 mg/dL occurred concurrently.
  - Participants with type 2 diabetes not using insulin had BG values within target range (70-180 mg/dL) 89% of the time.
  - Participants with type 2 diabetes using insulin were in target range 68% of the time.
  - Participants with type 1 diabetes were in target range 58% of the time.
  - Significant decrease in lab-measured A1c of 0.8% at 3 months (p=0.02) with a sustained decrease at 6 and 12 months for members not lost to follow-up.
  - Average PHQ-2 scores decreased by 0.56 points.



Whaley, Christopher M., Jennifer B. Bollyky, Wei Lu, Stefanie Painter, Jennifer Schneider, Zhenxiang Zhao, Xuanyao He, Jennal Johnson, and Eric S. Meadows. 2019. **“Reduced medical spending associated with increased use of a remote diabetes management program and lower mean blood glucose values.”** *Journal of Medical Economics*, 22:9, 869-877. <https://doi.org/10.1080/13696998.2019.1609483>

**Objective:** To investigate the financial impact of a remote digital diabetes management program using medical claims and real-time blood glucose data.

- Retrospective claims analysis N=11,002.
- Medical spending was compared between people well-controlled (BG ≤154 mg/dL) and poorly controlled (BG >154 mg/dL).
- Program was associated with:
  - 21.9% reduction in medical spending (\$88 savings PMPM) at one year (p<0.01).
  - 10.7% reduction in diabetes-related medical spending (p<0.01).
  - 24.6% reduction in spending on office-based services (p<0.01).
  - Well-controlled BG values were associated with 21.4% reduction in medical spending (p=0.03).



Bollyky, Jennifer B., Dena Bravata, Jason Yang, Mark Williamson, and Jennifer Schneider. 2018. **"Remote Lifestyle Coaching Plus a Connected Glucose Meter with Certified Diabetes Educator Support Improves Glucose and Weight Loss for People with Type 2 Diabetes."** *Journal of Diabetes Research*, vol. 2018. <https://doi.org/10.1155/2018/3961730>

**Objective:** To evaluate the incremental effects of adding lifestyle coaching on blood glucose, estimated A1c and weight.

- Randomized control trial N=330.
- Adults with type 2 diabetes, A1c >7.0%, BMI  $\geq$ 25.
- Study arms: no further intervention (n=75), a connected scale (n=115), scale + lightweight coaching (n=73), scale + intense coaching (n=67) for 12 weeks.
- A1c reduced from 8.5% to 7.5% across all groups (p=0.01).
- Greater weight loss (lbs) observed in high-intensity vs. lightweight coaching and scale only (-6.4, -4.1, -1.1; p=0.01).
- BG change (mg/dL): -19.4, -11.3, -2.8; p=0.02.
- Improvement in empowerment and well-being about managing diabetes measured by the Diabetes Empowerment Survey across all groups.



Downing, Janelle, Jenna Bollyky, and Jennifer Schneider. 2017. **"Use of a Connected Glucose Meter and Certified Diabetes Educator Coaching to Decrease the Likelihood of Abnormal Blood Glucose Excursions: The Livongo for Diabetes Program."** *Journal of Medical Internet Research*, 2017;19(7):e234. <https://doi.org/10.2196/jmir.6659>

**Objective:** To evaluate blood glucose data for members enrolled in the Livongo program.

- Retrospective analysis N=4,544.
- Oct. 2014-Dec. 2015.
- 18.4% decrease in the likelihood of a hypoglycemic event (BG <80) compared to baseline.
- 16.4% decrease in hyperglycemia (BG >180) compared to baseline.



Matsunami, Risë K., Kimon Angelides, and David A. Engler. **"Development and Validation of a Rapid  $^{13}\text{C}_6$ -Glucose Isotope Dilution UPLC-MRM Mass Spectrometry Method for Use in Determining System Accuracy and Performance of Blood Glucose Monitoring Devices."** *Journal of Diabetes Science and Technology*, 2015, 9, no. 5 (September): 1051–60. <https://doi.org/10.1177/1932296815586015>

**Objective:** To develop a completely orthogonal primary method to serve as a true standard reference measurement procedure for establishing the accuracy of new blood glucose monitoring systems.

- The newly developed ID UPLC-MRM assay can serve as a validated reference measurement procedure to which new blood glucose monitoring systems can be assessed for glucose measurement performance.



Angelides, Kimon, Risë K. Matsunami, and David A. Engler. **"Performance and System Validation of a New Cellular-Enabled Blood Glucose Monitoring System Using a New Standard Reference Measurement Procedure of Isotope Dilution UPLC-MRM Mass Spectrometry."** *Journal of Diabetes Science and Technology*, 2015, 9, no. 5 (September): 1061–70. <https://doi.org/10.1177/1932296815586016>

**Objective:** To evaluate the accuracy, precision and linearity of the In Touch® blood glucose monitoring system.

- The results show that the In Touch® meter exceeds the minimum criteria of both the ISO 15197:2003 and ISO 15197:2013 standards.
- The results from a user panel show that 100% of the respondents reported that the color touch screen, with its graphic user interface (GUI), is well-labeled and easy to navigate.



Lu, Wei, R.A. James, and Bimal Shah. 2020. **“Predictors of ED and Inpatient Admissions after Hypo- and Hyperglycemic Events: Leveraging Remote Monitoring Data of People with Diabetes.”** Presented to the 80th Scientific Sessions American Diabetes Association, Chicago, Illinois, June 12-16, 2020.

**Objective:** To determine if a model can be developed to predict ED visit and/or inpatient admission within three days of SMBG severe hypo- or hyperglycemia events leveraging a remote DM monitoring data platform (RDMP) to reduce costly healthcare utilization.



Perez-Nieves, M., Wei Lu, J.L. Poon, L. Fan, R.A. James, and Bimal Shah. 2020. **“Is Activation, Behaviors, and Attitudes to Managing Care Associated with Utilization of a Remote Diabetes Monitoring Platform (RDMP) and Improvement of A1c?”** Presented to the 80th Scientific Sessions American Diabetes Association, Chicago, Illinois, June 12-16, 2020.

**Objective:** To assess the relationship between PROMs that measure activation (PAM), empowerment (DES), and distress (DDS) and to evaluate the association of PROMs scores with RDMP usage and glycemic control (A1c) on the overall population and by insulin use.

- A cross-sectional observational survey study and retrospective secondary data analysis study of RDMP members that have participated on the platform for 12-18 months.
- PAM and DES scores were most correlated with each other ( $r=0.48$ ); neither were associated with A1c improvement.
- People with higher DES scores were 20% more likely to have high RDMP usage ( $p<0.05$ ).



Ellis, R.J., E. Townley-Smith, K. Kappaganthu, R.A. James, J.A. Bridgewater, and Bimal Shah. 2020. **“Evaluating a Behavioral Commitment Program to Sustain Engagement in a Digital Diabetes Management Platform.”** Presented to the Society of Behavioral Medicine 41st Annual Meeting & Scientific Sessions, San Francisco, California, April 1, 2020.

**Objective:** To evaluate if intention to change health behaviors will improve the frequency of blood glucose (BG) checks via a cellularly connected meter and associated mean BG values over three consecutive 30-day periods (“Post1,” “Post2,” “Post3”) relative to a 30-day “Pre” period.

- Retrospective analysis of the Five-Day Challenge in the DM program (eating vegetables, drinking water, walking more, sleeping well and reducing stress).
- 3,982 members completed at least one of the 25 Challenge steps (Participants), 4,276 completed 0 Challenge steps (Initiators). All other individuals were classified as Controls.
- After exact matching, each cohort had 3,308 individuals.
- At Post1 and Post3 relative to Pre, the percentage of each cohort achieving  $\geq 5$  checks was +10.9 points ( $p\text{-value} < 0.001$ ) and -1.3 points ( $p = 0.080$ ) for Participants; +3.4 points and -7.1 points for Initiators (both  $p\text{-value} < 0.001$ ); and -4.9 points and -12.3 points for Controls (both  $p < 0.001$ ).
- A significant decrease in mean BG from Pre to Post3 was larger among Participants (mean: -5.1 mg/dl, 95% CI: [-6.5, -3.7]) than Initiators (-4.1 mg/dl [-5.5, -2.7]); Controls saw a non-significant change (-0.7 mg/dl [-1.9, +0.6]).



Yu, J.S., R.A. James, Wei Lu, and J. Hoffman. 2020. **“Exploring the Relationship Between Diabetes, Stress, and Self-Management to Inform Chronic Disease Product Development.”**

Presented to the Society of Behavioral Medicine 41st Annual Meeting & Scientific Sessions, San Francisco, California, April 1, 2020.

**Objective:** To explore the relationship between stress and sequelae of DM among adults enrolled in a digital DM program (Livongo), in order to inform intervention and product development. Livongo provides enrolled members with a cellular-connected blood glucose (BG) meter, glucose test supplies and digital one-on-one coaching.

- Retrospective analysis N=3,263 of adults on the DM platform from June 2015 through 2018 N=3,263.
- Members who reported stress, compared to those who did not, had higher insulin usage (35.1% v. 28.9%,  $p < 0.001$ ), and poorer glycemic control throughout the study (ratio of BG readings  $> 180$  mg/dL =  $0.25 \pm 0.25$  v.  $0.21 \pm 0.26$ ,  $p < 0.001$ ).
- Members who reported stress and had at least 1 BH diagnosis/intervention, compared to those who did not.



Yu, J.S., R.A. James, T. Xu, Bimal Shah, and J. Hoffman. 2020. **“Leveraging Digital Behavioral Health to Increase Resilience Among People with Diabetes.”** Presented to the ADAA Anxiety and Depression Conference, San Antonio, Texas, March 19-22, 2020 (postponed due to COVID-19).

**Objective:** To determine if indicators of stress could be used to identify people who may need behavioral health (BH) management support.

- Retrospective analysis N=3,263 of adults on the DM platform from June 2015 through 2018 N=3,263.
- Participants were grouped based on the presence of self-reported stress and BH diagnosis/utilization.
- 1,808 participants (55%) recorded stress at the time of at least 1 BG reading; of these, 940 (52%) also had at least 1 BH diagnosis/utilization.
- Participants with 10 or more self-reported episodes of stress during BG checking that represented 9% or higher of checks during the study period had an increased likelihood of BH diagnosis [OR: 1.13, 95%CI of (1.03, 1.25)].



Munshi, K.D., C.A. Swift, C.S. Carter, and R.R. Henderson. 2019. **“Impact of a Diabetes Remote Monitoring Program on Medication Adherence.”** Presented to the AMCP Managed Care & Specialty Pharmacy Annual Meeting, San Diego, California, March 25-28, 2019.

**Objective:** To examine the relationship between patients' engagement with a diabetes remote-monitoring (DRM) program and adherence to oral diabetes drugs (OAD).

- Retrospective analysis utilizing propensity-matched controls in 1:2 ratio N=18,006.
- In patients engaged continuously for  $\geq 3$ ,  $\geq 6$  and  $\geq 12$  months in the DRM program had 5%, 5.2% and 6.4% higher adherence, respectively, compared to matched controls.
- The odds of being adherent were 52%, 64% and almost twice as high for patients engaged continuously for  $\geq 3$ ,  $\geq 6$  and  $\geq 12$  months, respectively, compared to matched non-DRM patients.

Bollyky, Jennifer, S. Painter, J.L. Poon, M. Perez-Nieves, and Bimal Shah. 2019. **"Connected Glucose Meter Plus CDE Coaching Improved Diabetes Patient Empowerment and Distress in Real-World Outcomes Setting."** Presented to 79th Scientific Sessions American Diabetes Association, San Francisco, California, June 7-11, 2019.

**Objective:** To understand the relationship between diabetes distress (DDS2) and diabetes empowerment (DES-SF) and the Livongo program.

- Retrospective analysis N=957.
- Leveraging the pre- or 1-month surveys and the 12-month survey, the analysis compared changes in responses.
- 61% of members had an improvement in DDS2 and DES-SF.
- 94% of members had improvement in at least one score.
- Livongo program usage with higher BG checking frequency was associated with higher likelihood of improvement in DDS2 and DES-SF.
- Upon multivariable adjustment, responders were less likely to be Asian, more likely to be younger, have a lower BMI and diabetes duration of 5-10 years.

Lu, Wei, S. Painter, Jennifer Bollyky, and Bimal Shah. 2019. **"Characteristics Associated with Improved Blood Glucose Control for a Large Diabetes Population Using a Connected Blood Glucose Meter With CDE Support."** Presented to 79th Scientific Sessions American Diabetes Association, San Francisco, California, June 7-11, 2019.

**Objective:** To investigate associations between usage of a two-way cellular-connected glucometer, real-time digital and human coaching, data-sharing, personalized feedback, improvements in estimated hemoglobin A1c (eA1c) and abnormal BG alerts (i.e., BG <50 mg/dL, BG >400 mg/dL or other member-customized values).

- Retrospective analysis N=33,996.
- Livongo members enrolled > 12 months with data for at least one outcome measure.
- Multivariable regression showed statistically significant ( $p < 0.05$ ) associations of:
  - likelihood of eA1c improvement was 34% higher with 1-on-1 coaching, 23% higher with BG sharing, 17% lower for members who opted out of BG alerting, 38% higher with HSR sharing with doctors.
  - likelihood of improvement in % of BG with alert was 9% higher with 1-on-1 coaching, 20% higher with BG sharing, 15% higher with HSR sharing with doctor.

Bollyky Jennifer, Wei Lu, and C.M. Whaley. 2018. **"Cost Savings Associated With Usage and Blood Glucose Control for Members of the Livongo for Diabetes Program."** Presented to 78th Scientific Sessions American Diabetes Association. Orlando, Florida, June 22-26, 2018.

**Objective:** To evaluate the financial impact of the Livongo program and claims data from self-insured employers.

- Retrospective propensity-matched difference-in-differences analysis N=10,412.
- Following the launch of Livongo, risk-adjusted total spending for users and non-users decreased by 11.8%.
- A 10% increase in the monthly Livongo usage rate is associated with a 2.1% decrease in decrease in associated medical spending ( $p < 0.01$ ), which was driven by a 2.9% reduction in spending on office-based services.
- Launch of Livongo led to a risk-adjusted 76.2% increase in the monthly use rate of Livongo.
- Mean monthly medical spending for users with mean BG <154 mg/dL was significantly lower than for users with mean BG >154 mg/dL (\$505.86 vs. \$681.01,  $p = 0.02$ ).



Lu, Wei, J. Schneider, and Jennifer Bollyky. 2018. **"Frequency of Hypoglycemia Events in a Large, Real-World Diabetes Population."** Presented to 78th Scientific Sessions American Diabetes Association. Orlando, Florida, June 22-26, 2018.

**Objective:** To investigate the incidence of hypoglycemic episodes for people on the Livongo for Diabetes program.

- Retrospective analysis N=63,817.
- Members (type 1 and type 2) using the program for 12 months.
- Multiple doses of insulin (MDI) per day and type 1 diabetes were associated with more hypoglycemic episodes.
- Members with type 1 and MDI had almost 50 episodes of hypoglycemia (BG <70 mg/dL) per year compared to 1-2 for members on oral antihyperglycemics.
- Members on oral antihyperglycemics had the highest percent of checks (81%) in the normal range (BG 70-180 mg/dL). Members with type 1 and MDI had the lowest percent of checks (49%) in the normal range.



Bollyky, Jennifer. 2018. **"Exploring Virtual Clinical Trials: Lessons from Clinical Care."** Presented to the National Academies of Sciences, Engineering, Medicine Virtual Clinical Trials: Challenges and Opportunities, Washington, D.C., 2018.

**Objective:** To discuss challenges with chronic condition management, real-world evidence partnerships, and use of digital tools for clinical research and medical product development.

- Oral presentation summarizing completed studies and the development process of new studies.



Ford, A, Wei Lu, J. Schneider, J. Bridgewater, and Jennifer Bollyky. 2018. **"Data Science Approach to Monitoring Health Status for a Diabetes Population."** Presented to the American Medical Informatics Association Informatics Summit, San Francisco, California, March 12-15, 2018.

**Objective:** To compare lab A1c values to values estimated using BG values from the Livongo meter and the ADAG study model.

- Retrospective analysis comparing lab A1c values to values estimated using the ADAG study model N=559.
- 86% of eA1c values fell within 20% of the lab values.
- Using SMBG values to estimate A1c is a reasonable approach to assessing health status for PwDs.



Schep, A, K. Kappaganthu, K. Xu, Wei Lu, Jennifer Bollyky, and J. Bridgewater. 2018. **"Driving Behavior Change in a Large Population of People with Diabetes using Stochastic and ML algorithms."** Presented to the Diabetes Technology Society, Rockville, Maryland, November 8-10, 2018.

**Objective:** To evaluate the impact of personalized messages delivered algorithmically prior to BG checking based on clinical guidelines using machine-learned behavior "nudges" to improve diabetes self-management behavior.

- Randomized control trial N=67,104.
- 2.5x completion of action within 3 days for members who received the nudges.
- Personalized messages delivered via connected glucose meter based on stochastic and machine-learned models can improve diabetes self-management behaviors, including BG checking frequency.



Amante, D.J., T.P. Hogan, S.L. Pagoto, et al. 2017. **“Evaluation of a Diabetes Care Support Program facilitated by Cellular-Enabled Glucose Meters.”** Presented to the 77th Scientific Sessions American Diabetes Association, San Diego, California, June 9-13, 2017.

**Objective:** To evaluate the Livongo program on improving glucose control (UMASS).

- Randomized control trial with crossover design N=120.
- Type 2 diabetes with A1c > 8.0%.
- Group 1: intervention for 6 months, then usual care for 6 months.
- Group 2: usual care for 6 months, then intervention for 6 months.
- 0.44% absolute reduction in A1c at 12 months for Group 2.
- 0.28% absolute increase in A1c at 12 months for those in Group 1 who were on program and then stopped.
- Program is associated with improved A1c.

Bollyky, Jennifer, C. Whaley, and J. Schneider. 2017. **“Connected Glucose Meter Plus Coaching Improves Diabetes Clinical Outcomes and Decreases Costs.”** Presented to the 77th Scientific Sessions American Diabetes Association, San Diego, California, June 9-13, 2017.

**Objective:** To evaluate the impact of the Livongo for Diabetes program on clinical and financial outcomes.

- Retrospective analysis of two self-insured employer clients N=15,539.
- 8% less likely to have low BG readings.
- 18% less likely to have high BG readings.
- 1.2% decrease in A1c at 12 months.
- 3.7% reduction in total cholesterol.
- 5.8% decrease in total allowed spending amount (\$83.06 PMPM saving).

Bollyky, Jennifer, D. Bravata, J. Yang, J. Schneider. 2017. **“Lifestyle Coaching Plus Connected Glucose Meter with CDE Support Improves Blood Glucose and Weight Loss for People with Type 2 Diabetes.”** Presented to the 77th Scientific Sessions American Diabetes Association, San Diego, California, June 9-13, 2017.

**Objective:** To evaluate the incremental effects of adding lifestyle coaching on blood glucose, estimated A1c and weight.

- Randomized control trial N=330.
- Adults with type 2 diabetes, A1c >7.0%, BMI ≥25.
- Study arms: no further intervention (N=5), a connected scale (N=115), scale + lightweight coaching (N=73), scale + intense coaching (N=67) for 12 weeks.
- A1c reduced from 8.5% to 7.5% across all groups (p=0.01).
- Greater weight loss (lbs) observed in high-intensity vs. lightweight coaching and scale only (-6.4, -4.1, -1.1; p=0.01).
- BG change (mg/dL): -19.4, -11.3, -2.8; p=0.02.

Amante, D.J., M.E. Fox, D.M. Harlan, and M.J. Thompson. 2016. **“Examining feasibility and preliminary efficacy of a diabetes care support program facilitated by cellular-enabled glucose meters.”** Presented to the 76th Scientific Sessions American Diabetes Association, New Orleans, Louisiana, June 10-14, 2016.

**Objective:** To evaluate the Livongo program on improving glucose control (UMASS).

- Randomized control trial with crossover design N=120.
- Type 2 diabetes with A1c > 8.0%.
- Intervention had 1.1% reduction in A1c compared to 0.7% reduction for control (p=0.07).
- 83% of intervention participants had improved A1c recordings at 6 months compared to 71% of control participants.



Downing, Janelle, Jennifer Bollyky, and Jennifer Schneider. 2016. **"Coaching Coupled with Real-Time Data Improves Blood Glucose."** Presented to the 76th Scientific Sessions American Diabetes Association, New Orleans, Louisiana, June 10-14, 2016.

**Objective:** To compare blood glucose control in people using a cellular-enabled BG meter and telephonic coaching.

- Retrospective analysis N=10,741.
- Members who received coaching were:
  - more likely to be type 1, be female and use insulin.
  - mean BG decreased by 33 mg/dL after the first personalized coaching session.
  - mean estimated A1c decreased by 0.5% ( $p<0.01$ ) after 3 months of program participation and was sustained at 270 days.

Downing, Janelle, Jennifer Bollyky, and Jennifer Schneider. 2016. **"Fewer Days with High and Low Blood Glucose Readings and HbA1c Reduction with Cellular-Enabled Glucose Meter."** Presented to the 76th Scientific Sessions American Diabetes Association, New Orleans, Louisiana, June 10-14, 2016.

**Objective:** To assess diabetes control over time for members enrolled in the Livongo Diabetes program.

- Retrospective analysis N=7,428.
- 15% average reduction in the likelihood of having a day with a high BG value reading in Months 2-12 compared to Month 1 ( $p<0.001$ ).
- 18% average reduction in the likelihood of having a day with a low BG reading in Months 2-12 compared to Month 1 ( $p<0.001$ ).
- Mean A1c decreased from 7.7% at registration to 7.0% at Day 90 of program participation.

Pulizzi, J., Jennifer Bollyky, A. Toles, M. Boulos, and Jennifer Schneider. 2016. **"Targeted Diabetes Education Text Messaging Program Increases Requests for CDE Coaching and Improves Blood Glucose Trends."** Connected Health Symposium, Boston, Massachusetts, *Journal of Medical Internet Research Publications*, October 20-21, 2016.

**Objective:** To determine whether diabetes education offered to a targeted population via text messages for 4 weeks would increase requests for telephonic CDE coaching and improve BG control.

- Observational study N=496.
- People with diabetes and a self-reported A1c > 7% during 2017.
- Text messaging triggered 38 personalized CDE coaching sessions (7.8%) compared to 4.0% of members.
- Engaging people with diabetes education in a targeted and personalized manner helps connect members with CDE coaches and improve blood glucose control.

Toles, A., M. Boulos, J. Pulizzi, Jennifer Bollyky, and Jennifer Schneider. 2016. **"Nutrition Text Messaging Program Increases Blood Glucose Checking Frequency and CDE Coaching Requests for People with Diabetes."** Presented to the Diabetes Technology Society, Rockville, Maryland, November 10-12, 2016.

**Objective:** To determine if personalized nutrition messages to people with diabetes would increase requests for coaching and to set and achieve diabetes-related health goals.

- Retrospective analysis of a 15-week text message program for members with A1c > 7%. N=69 with 59 completing the project.
- 18% of participants requested coaching compared to 4% of non-participants.
- Mean BG checks increased for participants from 2.1 checks/day to 2.6 in the last 30 days of the program.



Abhulimen, Sese, and Abigail Hirsch. 2018. **"Quantifying the economic impact of a digital self-care behavioral health platform on Missouri Medicaid expenditures."** *Journal of Medical Economics*, 21(11), 1084–1090. <https://doi.org/10.1080/13696998.2018.1510834>

**Objective:** To estimate the economic benefits relative to return on investment of a statewide initiative to integrate digital behavioral health self-care into the community system.

- Retrospective propensity-matched analysis N=1,514.
- Medicaid population in Missouri.
- 4.8x ROI.
- \$382 savings per user.
- Biggest savings in emergency, ambulatory and inpatient services.



Schladweiler, Krista, Abigail Hirsch, Ed Jones, and Luke B. Snow. 2017. **"Real-World Outcomes Associated with a Digital Self-Care Behavioral Health Platform."** *Annals of Clinical Research and Trials*, 2017, 1(2):1-5. <https://scionline.org/abstract/21630/Real-World-Outcomes-Associated-with-a-Digital-Self-Care-Behavioral-Health-Platform>

**Objective:** To demonstrate improvement in depressive symptoms among employees at risk of depression through myStrength use.

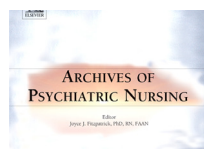
- Randomized control trial N=146.
- Study arms: myStrength vs. Depression emails.
- Commercially insured employees.
- More rapid reduction in symptoms of depression even in non-clinical sample ( $p < 0.001$ ).
- Results comparable to Able To Pande, et al.



Schladweiler, Krista, Abigail Hirsch, Ed Jones, and Luke B. Snow. 2017. **"Real-World Outcomes Associated with a Digital Self-Care Behavioral Health Platform."** *Annals of Clinical Research and Trials*, 2017, 1(2):1-5. <https://scionline.org/abstract/21630/Real-World-Outcomes-Associated-with-a-Digital-Self-Care-Behavioral-Health-Platform>

**Objective:** To evaluate the real-world effectiveness of managing depression on the population level using myStrength, a digital self-care behavioral health and well-being platform.

- Observational, longitudinal study N=2,138.
- Commercially insured symptomatic employees.
- MS Effect size: 0.66 population [95% CI: 0.60, 0.73]; 1.02 for clinical depression [95% CI: 0.95, 1.13].
- 82% as effective as benchmark for therapy.
- Most improvement in first 14 days of use.



Ahmedani, Brian K., T. Belville-Robertson, A. Hirsch, and A. Jurayj. 2016. **"An Online Mental Health and Wellness Intervention Supplementing Standard Care of Depression and Anxiety."** *Archives of Psychiatric Nursing*, December 2016, 30(6):666-670. <https://doi.org/10.1016/j.apnu.2016.03.003>

**Objective:** To study the feasibility, acceptability and preliminary effectiveness of an online intervention supplementing standard care of depression and anxiety.

- Pilot on acceptability in a health system N=96.



Hirsch, A., J. Albright, and A. Link. 2018. **“Digital Tools for Chronic Pain Management: An innovative approach to building awareness of non-opioid based pain management techniques.”** Poster presented at the International Society for Pharmacoeconomics and Outcomes Research, Baltimore, Maryland, 2018.

**Objective:** To evaluate the impact of myStrength, a digital behavioral health platform, on chronic pain management, as well as depression, anxiety, insomnia, stress and substance use disorder, compared to treatment as usual.

- Randomized control trial N=134.
- Evaluated the feasibility and acceptability of adding asynchronous chat-based coaching to the myStrength digital BH platform.
- The added human element helped participants feel supported in their struggles with BH issues and has the potential to help increase engagement to myStrength effective, evidence-based well-being resources.



Link, A., and A. Hirsch. 2018. **“Cost Impact of the Statewide Introduction of a Digital Behavioral Health Tool: Results of an evaluation of myStrength in the state of Missouri.”** Poster presented at the International Society for Pharmacoeconomics and Outcomes Research, Baltimore, Maryland, 2018.

**Objective:** To evaluate the feasibility and acceptability of adding asynchronous chat-based coaching to the myStrength digital platform.

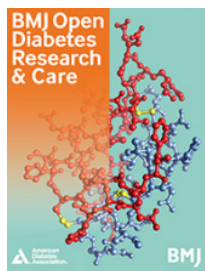
- Observational study N=1,514.
- Platform was well-received, perceived as helpful and promoted a more personalized experience.



Link, A., A. Lukowski, and A. Hirsch. 2018. **“The addition of asynchronous chat-based coaching to a digital health tool promotes support and personalization.”** Poster presented to the Connected Health Conference, Boston, Massachusetts, October 17-19, 2018.

**Objective:** To evaluate the impact of myStrength, a digital behavioral health platform, on chronic pain management, as well as depression, anxiety, insomnia, stress and substance use disorder, compared to treatment as usual.

- N=134.
- Adding asynchronous coaching was well-received, perceived as helpful and promoted a more personalized experience with the digital BH tool.
- Users felt supported.



Painter, Stefanie L., Wei Lu, Jennifer Schneider, Roberta James, and Bimal Shah. 2020. **“Drivers of weight loss in a CDC-recognized digital diabetes prevention program.”** *BMJ Open Diabetes Research and Care*, 2020;8:e001132. <https://drc.bmj.com/content/8/1/e001132>

**Objective:** To investigate the impact of the digital Livongo Diabetes Prevention Program (DPP) on weight at 12 months, understand participant self-monitoring behaviors associated with greater weight loss and evaluate the impact of coaching interactions on more frequent self-monitoring behaviors.

- Retrospective analysis of DPP participants during 2016-2017 (N=2,037).
- Participants lost on average 5.1 % of their starting weight. Highly engaged participants lost 6.6% of starting body weight with 25% losing  $\geq 10\%$  at 12 months.
- Logistic regression analysis showed each submitted food log was associated with 0.5 lbs ( $p < 0.05$ ) weight loss, each lesson completed was associated with 0.3 lb ( $p < 0.05$ ) weight loss and a week of 150 active minutes was associated with 0.2 lbs ( $p < 0.01$ ) of weight loss.
- One additional coach-participant message each week was associated with 1.4 more food logs per week, 1.6% increase in weeks with four or more weigh-ins and a 2.7% increase in weeks with 150 minutes of activity.



Painter, S.L., R. Ahmed, R.F. Kushner, et al. 2018. **“Expert Coaching in Weight Loss: Retrospective Analysis.”** *Journal of Medical Internet Research*, 2018, 20(3). <https://doi.org/10.2196/jmir.9738>

**Objective:** To examine the association between different methods of coach-participant interaction and weight loss and tried to understand the level of coaching impact on weight loss.

- Retrospective analysis of enrolled Retrofit participants (age  $> 17$ , BMI  $\geq 25$ , at least one weight value post-baseline assessment from 2011 to 2016) N=1,423.
- Significant predictors of weight loss at 6 months: expert coaching session attendance ( $p < .001$ ), live weekly web-based class attendance ( $p < .001$ ) and food log feedback days per week ( $p < .001$ ).
- Attending 80% of expert coaching sessions, attending 60% of live weekly web-based classes and receiving a minimum of one food log feedback day per week were associated with weight loss  $\geq 5\%$ .



Painter, S.L., R. Ahmed, J.O. Hill, R.F. Kushner, R. Lindquist, S. Brunning, and A. Margulies. 2017. **“What Matters in Weight Loss? An In-Depth Analysis of Self-Monitoring.”** *Journal of Medical Internet Research*, 2017, 19(5):e160. <https://doi.org/10.2196/jmir.7457>

**Objective:** To analyze the contribution of self-monitoring to weight loss in participants in a 6-month commercial weight-loss intervention.

- Retrospective analysis of enrolled Retrofit participants from 2011 to 2015 N=2,113.
- Participants lost a mean 5.6% of their baseline weight with 51.9% losing at least 5%.
- Weighing in at least three times per week, having a minimum of 60 highly active minutes per week, food logging at least three days per week, and having 64% (16.6/26) or more weeks with at least five food logs were associated with clinically significant weight loss ( $\geq 5\%$ ) for both male and female participants.

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Painter, Stefanie, Gary Ditsch, Rezwan Ahmed, Nicholas Buck Hanson, Kevin Kachin, and Jan Berger. 2016. **"Retrofit Weight-Loss Outcomes at 6, 12, and 24 Months and Characteristics of 12-Month High Performers: A Retrospective Analysis."** *JMIR Mhealth Uhealth*, 2016, 4(3):e101. <https://doi.org/10.2196/mhealth.5873>

**Objective:** To report Retrofit's weight-loss outcomes at 6, 12 and 24 months and characterize behaviors, age and sex of high-performing participants who achieved weight loss of 10% or greater at 12 months.

- Retrospective analysis of enrolled Retrofit participants from 2011 to 2014 N=2,720.
  - Average weight loss at 6, 12 and 24 months was 5.2%, 5.8% and 4.1%, respectively.
  - Participants with  $\geq 10\%$  weight loss had greater adherence to weighing in, number of days wearing an activity tracker and higher average number of steps per day.
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Painter, Stefanie, Wei Lu, Jennifer Bollyky, and Bimal Shah. 2019. **“Drivers of Weight Loss in a CDC-Recognized Virtual Diabetes Prevention Program.”** Presented to the 79th Scientific Sessions American Diabetes Association, San Francisco, California, June 7-11, 2019.

**Objective:** To investigate self-monitoring behaviors that are drivers of weight loss by engagement status.

- Retrospective analysis of participants enrolled in the Livongo DPP program who complete Lesson 1 and recorded a starting weight between 2016 and 2017 N=2,037.
  - 32.3% of participants were classified as highly engaged (CDC criteria).
  - Mean percent weight loss was 5.1% at 12 months (11.1 lbs).
  - Regression analysis showed weight loss was statistically associated with the following self-monitoring behaviors:
    - 0.4 lbs (0.2%) by attending one more lesson.
    - 0.5 lbs (0.3%) by one more food log per week.
    - 0.2 lbs (0.1%) by one more week of 150 active minutes.
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Xu, K., R. James, Wei Lu, A. Sangha, and Bimal Shah. 2019. **“More Frequent Remote Home Monitoring Decreases Blood Pressure in an Unselected Population of People with Diabetes.”** Presented at the American Heart Association Scientific Session, Philadelphia, Pennsylvania, November 16-18, 2019.

**Objective:** To evaluate remote monitoring of blood pressure in a diabetes population for a longer follow-up period of 12 weeks.

- Retrospective analysis of members with HTN and diabetes with > 5 BP readings during a 12-week period between April 25, 2018, and May 28, 2019, N=1,690.
- Members with Uncontrolled HTN (BP  $\geq$ 130/80) had a decrease in BP of 7.2 / 4.0 ( $p<0.001$ ).
- Members with Stage 2 HTN (BP  $\geq$ 140/90) had a decrease in SBP of 10.2 at week 4 that decreased further to 12.7 by week 12.
- Age, baseline BP and number of home BP monitoring readings were statistically associated with reduction in SBP and DBP ( $p<0.05$ ).



Bollyky, Jennifer, T. Xu, Wei Lu, and Bimal Shah. 2019. **“Remote Monitoring of Blood Pressure in a Diabetes Population Decreases Blood Pressure at 6 Weeks: A Pilot Study.”** Presented at the American College of Cardiology 68th Annual Scientific Session and Expo, New Orleans, Louisiana, March 16, 2019.

**Objective:** To evaluate remote monitoring of blood pressure in a diabetes population.

- Retrospective analysis of members with HTN and diabetes with > 5 BP readings during a 6-week period between May 2018 and January 2019 N=708.
- Members with Stage 2 HTN had mean decreases of 10 mmHg for SBP and 6 mmHg DBP ( $p<0.05$ ) with 15% reaching well-controlled status.
- Members with Stage 1 HTN had mean decreases of 2 mmHg for SBP and DBP ( $p<0.05$ ) with 34% reaching well-controlled status.

#### ABBREVIATIONS:

**A1c:** HbA1c to measure glycated hemoglobin

**BG:** blood glucose

**BH:** behavioral health

**BMI:** body mass index

**BP:** blood pressure

**DBP:** diastolic blood pressure

**DDS2:** Diabetes Distress Scale Short Form

**DES-SF:** Diabetes Empowerment Scale Short Form

**HTN:** hypertension

**ISO:** International Organization for Standardization

**PMPM:** per member per month

**SBP:** systolic blood pressure

**T2D:** Type 2 diabetes

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