Objective: Diabetes research on work productivity has been largely cross-sectional and retrospective, with only one known randomized controlled trial (RCT) published, to our knowledge. Secondary analysis of the Fit-One RCT tested the effect of One Drop’s digital health program on workplace productivity outcomes, absenteeism, and presenteeism, for employees and specifically for older workers with type 2 diabetes. Methods: Analysis of the 3-month Fit-One trial data from employees who have type 2 diabetes explored productivity using logistic analyses and generalized estimating equations. Results: Treatment and control group comparisons showed that workers (N = 125) using One Drop see direct benefits to workplace productivity, which leads to productivity savings for employers. Conclusion: This was the first RCT to demonstrate that a mobile health application for managing type 2 diabetes can positively affect productivity at work.

Keywords: productivity, mobile health, diabetes, health tech, employees, cost savings, occupational health, digital health

One Drop Improves Productivity for Workers With Type 2 Diabetes

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people with diabetes. That RCT examined the productivity (absenteeism and presenteeism) of individuals with type 2 diabetes using a personal digital assistant, chronic disease self-management program, or both, and found no evidence that these tools benefited productivity. A majority of studies, to date, that have investigated mHealth interventions in the workplace have been interventions that promote physical activity and reduced sedentary behavior, as well as mental health management. The StopDia RCT is currently underway to explore the use of a digital health intervention to reduce the risk of developing type 2 diabetes with the effect on productivity as a secondary outcome; however, no results from this trial have been published to date. Our review of the literature found limited research specifically examining the utility of mHealth interventions on work productivity among individuals with diabetes. To date, the present randomized experimental study design is the first to test whether an mHealth solution for managing chronic conditions can affect productivity among workers with type 2 diabetes.

The present study evaluates One Drop, a digital precision health solution that integrates a mobile app with one-on-one personalized coaching, educational content, data-driven feedback, blood glucose forecasting, and automated health information logging via connected devices. One Drop has been shown to significantly improve A1c outcomes for people with diabetes. The current study investigates workplace productivity outcomes for workers with type 2 diabetes who use the One Drop mHealth solution compared with a control group and focuses specifically on understanding these effects in workers older than 50 years. We perform secondary analysis of the Fit-One RCT data set to experimentally evaluate the effects of One Drop compared with a control group on health-related presenteeism, defined as missing work due to health issues, and health-related presenteeism, defined as showing up to work but lacking typical productivity due to health issues. In addition to testing the effects of One Drop on absenteeism and presenteeism for all workers, we specifically investigate workers older than 50 years to assess those who may be more susceptible to health-related productivity loss. In addition, we separately assess workers who experience presenteeism at baseline to better understand productivity decline among all workers, especially those older than 50 years. Lastly, we estimate cost savings associated with the productivity changes observed. Through this research, we provide data from a robust study design to address a clear gap in the literature and answer the call by the Journal of Occupational/Environmental Medicine for research on the connection between business practices and health outcomes.

METHODS

Participants and Procedure

Data for the current study were collected as part of a 3-month RCT, the Fit-One Trial, designed to test the effects of One Drop and a wearable activity tracker on hemoglobin A1c (HbA1c) outcomes for people with type 1 and type 2 diabetes (see Osborn et al21 for further details including study flow diagram). The Fit-One RCT used a private institutional review board for approval of study procedures before recruitment. In the original data collection, study forms and self-report surveys were administered on-line, whereas A1c blood samples were self-collected and mailed to a laboratory for processing. Surveys and an A1c blood sample were completed at baseline and 3 months after baseline. Participants in the treatment condition with the One Drop program were given access to the digital solution including the mobile app, in-app direct messaging with a health coach, a Bluetooth-connected blood glucose meter, and a 3-month supply of test strips. Participants in the waitlist control group did not have access to all that is included in the One Drop program until after the study was complete. All participants were compensated for their time with free continued access to One Drop’s solution and continued use of the Bluetooth-enabled devices after the study ended.

Participants had never used One Drop before randomization into either the treatment with One Drop or the waitlist control groups. The present study is a secondary analysis of trial data filtered to include study participants who were employed with type 2 diabetes (HbA1c >7%) and completed the Work Productivity and Activity Impairment scale.

Measures

Demographics

The baseline survey collected self-reported age, sex, race, and insurance status.

Diabetes Information

The baseline survey collected self-reported date of diagnosis with type 2 diabetes. Diabetes duration was calculated as the number of years elapsed between self-reported date of diagnosis and the date the baseline survey was completed.

Absenteeism

The six-item Work Productivity and Activity Impairment scale was administered at baseline and in follow-up surveys. The item specifically used to measure absenteeism prompted participants to reflect on the past week and asked, “During the past seven days, how many hours did you miss from work because of your health problems?” The absenteeism variable used a ratio of missed work to total scheduled work hours that week, to develop a percentage of missed work due to illness. Thus, higher scores reflect greater absence from work.

Presenteeism

Presenteeism was measured using a different item from the six-item Work Productivity and Activity Impairment scale, both at baseline and follow-up. Participants were prompted to reflect on the past week and asked, “During the past seven days, how much did your health affect your productivity while you were working?” Participants responded on a 10-point scale from 0 (“Health problems had no effect on my work”) to 10 (“Health problems completely prevented me from working”). The presenteeism variable is expressed as a percentage of impairment at work, with a higher percentage indicating greater impairment and thus less productivity.

Estimated Cost Savings

Estimated cost savings due to presenteeism were calculated according to the methodology described by Goetz et al. The change in percentage of impairment at work attributable to the One Drop treatment was calculated by subtracting the difference in presenteeism from baseline to follow-up between the treatment and control groups. This difference was multiplied by 240 eligible working days in a year to obtain an estimated total number of productive days gained in a year due to One Drop. The US Bureau of Labor Statistics reports that the average hourly cost for employee compensation is $40.35, or $322.80 per day. This daily cost was multiplied by the estimated productive days saved in a year to estimate yearly employer cost savings.

Analyses

To ensure that randomization successfully distributed baseline characteristics between the treatment and control groups, between-group differences were assessed for sex, age, race, insurance status, diabetes duration, and baseline HbA1c. Differences were tested with independent-samples t tests for continuous variables and chi-squared tests for categorical variables.

Given the RCT design of the study, intention-to-treat (ITT) and per-protocol (PP) analyses were used to assess productivity data. Intention-to-treat analyses explored all participants who took part in the study, regardless of whether they followed up 3 months later, thus including all those we intended to treat. The PP analyses explored only
TABLE 1. Sample Descriptives

| Variable                              | Full Sample | Treatment | Control | P       |
|---------------------------------------|-------------|-----------|---------|---------|
|                                       | All (n=125) | 63 (49%)  | 62 (49%)| 0.41    |
| Sex, n (%)                            |             |           |         |         |
| Male                                  | 53 (42%)    | 29 (46%)  | 24 (39%)|         |
| Female                                | 72 (58%)    | 34 (54%)  | 38 (61%)|         |
| Age, mean (SD), yr                    | 48.8 (8.0)  | 48.3 (9.1)| 49.5 (6.8)| 0.40 |
| Race, n (%)                           |             |           |         | 0.30    |
| White                                 | 88 (70%)    | 47 (75%)  | 41 (66%)|         |
| Not White                             | 37 (30%)    | 16 (25%)  | 21 (34%)|         |
| Insurance status, n (%)               |             |           |         | 0.64    |
| Insured                               | 120 (96%)   | 61 (97%)  | 59 (95%)|         |
| Uninsured                             | 5 (4%)      | 2 (3%)    | 3 (5%)  |         |
| Years diagnosed with T2D, mean (SD)   | 8.9 (6.1)   | 8.3 (5.9)| 9.5 (6.2)| 0.25 |
| Baseline HbA1c, mean (SD), %          | 8.6 (1.5)   | 8.7 (1.5)| 8.6 (1.4)| 0.80 |

HbA1c, hemoglobin A1c; SD, standard deviation; T2D, type 2 diabetes.

RESULTS

Demographics

Each of the samples was mostly female, White, middle aged, and with health insurance (Table 1; Supplemental Table 1, http://links.lww.com/JOM/B93).

No between-group differences for sex, age, race, insurance status, diabetes duration, or HbA1c were found between groups within any of the samples (P > 0.05; Table 1; Supplementary Table 1, http://links.lww.com/JOM/B93).

Full Sample Analyses

Intention to Treat

Absenteeism logistic analyses found a nonsignificant effect of group when controlling for baseline (Table 2).

Presenteeism GEE analyses showed a significant group effect (B = -0.431, P = 0.044), such that those in the treatment group were less likely to experience presenteeism at follow-up, controlling for baseline (Table 3).

Per Protocol

Absenteeism logistic analyses were not significant, indicating that the odds of absenteeism at follow-up were not dependent on the intervention condition when controlling for baseline. It is worth noting that, although the logistic regression analyses showed nonsignificant effects of group for absenteeism, the odds ratios were in the direction of intervention having a benefit (Table 2).

TABLE 2. Logistic Regression Models for ITT and PP Analyses for Absenteeism

|                        | B     | OR (95% CI) | P     |
|------------------------|-------|-------------|-------|
| Full sample            |       |             |       |
| ITT: group effect on absenteeism | -0.212 | 0.81 (0.34–1.92) | 0.629 |
| PP: group effect on absenteeism | -0.376 | 0.69 (0.26–1.81) | 0.446 |
| 50-yr-and-older sample |       |             |       |
| ITT: group effect on absenteeism | -1.212 | 0.30 (0.07–1.27) | 0.101 |
| PP: group effect on absenteeism | -1.720 | 0.18 (0.03–1.03) | 0.053 |

The control group was used as the reference group. Baseline absenteeism was controlled for in all models.

CI, confidence interval; OR, odds ratio; PP, per-protocol; ITT, intent-to-treat.
The effect of group in the GEE model of presenteeism was not significant when controlling for baseline (Table 3).

**Older Worker Sample**

**Intention to Treat**

Absenteeism logistic analyses detected a marginal group effect when controlling for baseline (odds ratio, 0.30; 95% confidence interval, 0.07 to 1.27; $P = 0.101$; Table 2).

Presenteeism GEE analyses showed a significant group effect ($B = -2.007, P < 0.001$), such that those in the treatment group were less likely to experience presenteeism at follow-up, controlling for baseline. Furthermore, analyses showed a significant interaction of baseline presenteeism with group ($B = 0.029, P = 0.006$), indicating One Drop use (treatment) had a stronger effect for people with lower presenteeism at baseline (Table 3).

**Per Protocol**

For participants who reported presenteeism, the GEE analyses showed a significant effect of group ($B = -0.395, P = 0.032$) on follow-up presenteeism while controlling for baseline (Table 3).

**Older Workers Who Experienced Presenteeism at Baseline Sample**

**Intention to Treat**

The GEE results showed a significant effect of group ($B = -1.911, P = 0.007$) and a significant interaction effect of baseline presenteeism with group ($B = 0.027, P = 0.043$), indicating that treatment had a stronger effect for people with lower presenteeism (Table 3).

**Per Protocol**

For participants 50 years or older who experienced presenteeism, GEE analyses found a significant effect of group ($B = -1.919, P = 0.006$) and a significant interaction effect of baseline presenteeism with group ($B = 0.027, P = 0.043$), indicating that treatment had a stronger effect for people with lower presenteeism, replicating the ITT presenteeism results (Table 3).

**TABLE 4.** Per-Protocol GEE Analyses: Estimated Means of Follow-up Presenteeism

| Condition | Baseline Presentee | n | Mean, % |
|-----------|--------------------|---|---------|
| Age 50 yr and older | Control Low | 15 | 16.0 |
| | Control High | 12 | 48.7 |
| | Treatment Low | 8 | 3.3 |
| | Treatment High | 10 | 41.3 |
| Age 50 yr and older and experienced presenteeism at baseline | Control Low | 7 | 34.7 |
| | Control High | 10 | 45.0 |
| | Treatment Low | 8 | 8.4 |
| | Treatment High | 6 | 44.8 |

Low and high baseline presenteeism determined, respectively, by values below and above sample medians. Total N across each sample is not equal to the total N analyzed in PP analyses because participants with baseline presenteeism equal to their sample medians were pruned. Median baseline presenteeism was 20% for the 50-year-and-older sample and 30% for the 50-year-and-older and experienced presenteeism at baseline sample.

GEE, generalized estimating equation.
This interaction is visualized in Figure 2 using the procedure described in the PP results for the older worker sample. Estimated means for follow-up presenteeism segmented by group and level of baseline presenteeism are displayed in Table 4.

DISCUSSION

Summary of Findings and Implications

This is the first RCT to examine the effect of the One Drop mHealth solution on workplace productivity among persons with type 2 diabetes. Intention-to-treat analyses showed that participants in the control group experienced increased presenteeism after 3 months (ie, increased on-the-job productivity loss), whereas those in the treatment group who used One Drop reported decreased presenteeism (ie, reduced productivity loss). Analyses for presenteeism looking at older workers showed that One Drop use had a stronger benefit for older workers with lower presenteeism. Those who experienced less presenteeism at baseline and used One Drop experienced a significant benefit to their productivity, as they were less likely to experience presenteeism at follow-up (ie, were less likely to experience on-the-job productivity loss). The interaction for those who experienced presenteeism at baseline and were older than 50 years indicates that using One Drop is especially beneficial for older workers who experience lower presenteeism.

The One Drop treatment tested has a beneficial impact on productivity for workers dealing with type 2 diabetes through presenteeism. One Drop’s mHealth program offers many ways to engage and manage...
health, allowing personalization to individual needs. This mHealth option for diabetes management has a broader impact to the individual beyond simply impacting direct health outcomes to impacting occupational health as well. Finally, although we will not interpret the marginal effects seen for absenteeism among those 50 years and older, we do note that absenteeism may be a more challenging productivity outcome to impact. This could be because individuals are more likely to struggle through their health issues, allowing it to impact work through presenteeism rather than missing work (absenteeism).

The results from this RCT showed that One Drop members who fully engage when using the service can improve their work productivity. In addition to One Drop program’s immediate health benefits as previously shown, positive changes to productivity shown here have implications for improved job satisfaction, promotion potential, job security, and continued career development. Employers stand to gain directly from decreased spending on health insurance for their employees as well as reducing the indirect costs associated with productivity loss. For older workers, using One Drop saved 17% of on-the-job productivity over the 3-month trial, which equates to $13,106 saved annually per person. For all participants reporting presenteeism, using One Drop saved 9% of productivity over the 3-month study period, which equates to saving $6772 per person annually. Finally, for older workers who reported presenteeism, using One Drop saved 19% of on-the-job productivity over the 3-month trial, which equates to $14,913 saved annually per person. These results suggest that by using mHealth programs, such as One Drop, employees and employers will benefit from the improved workplace productivity as well as the previously established improvements to health outcomes.

Limitations and Future Directions

Although this study employed an experimental design using validated instruments to measure productivity outcomes (Work Productivity and Activity Impairment scale), as is the case with all studies, there are limitations to acknowledge. The information gathered from study participants was self-reported, which may reduce the validity because intentions of questions could not be clarified when needed and inconsistent responses were not probed for a more accurate representation of the participant’s intention. In addition, the self-reported nature of data collection opens the possibility of recall bias in the responses; however, the survey asked participants to reflect on the past week, which is a short-enough time frame to mitigate this bias. Furthermore, the survey did not collect information regarding the variety of job types and industries the participants work in. This prevents a more nuanced contextualization to our results and understanding of how these results might differ by industry.

This study was the first to use an RCT design to experimentally evaluate productivity changes in adults with diabetes from using a digital solution. Furthermore, this study design is the criterion standard for limiting bias and confounding. It is an important first step in studying an mHealth app’s impact on variables outside of clinical health outcomes with respect to diabetes, specifically, studying implications for an individual’s work productivity. Future research should explore and replicate these findings in a real-world setting to increase the generalizability of the mHealth-productivity effects and with larger study populations.

Health-related productivity declines at work, such as absenteeism and presenteeism, affect both the individual and the organization carrying the burden of lost productivity. Absenteeism and presenteeism are low base rate phenomena and must therefore be studied specifically among those who experience it. Furthermore, productivity research is needed to examine the effect of mHealth programs on productivity in relation to other illnesses beyond diabetes. The potential for mHealth programs to impact not only the health outcomes of the individual but also other aspects of their life also needs to be further elucidated; the COVID-19 pandemic, for example, has wide-ranging effects not fully understood. Recent research shows that the pandemic has impacted health-related productivity of workers across nearly every industry. Probst and colleagues explored the impact of the workplace environment on employee attitudes and subsequent presenteeism. In conjunction with the present study, this highlights an avenue for future research to explore how mHealth apps could benefit workplace and health outcomes with consideration for chronic health conditions.

Conclusion

The present study is the only RCT to examine the productivity gains found by using an mHealth app for workers with diabetes, as the only previous RCT we are aware of found no benefit to productivity with the self-management program they assessed. To date, previous research has demonstrated the health benefits of using One Drop’s digital health solution. The present study shows that using One Drop is also beneficial for employee productivity, especially for older workers, which may translate into improved job security, career advancement, and job satisfaction for individuals. The productivity gains demonstrated in this study can benefit employers too, as mitigating the deleterious effects of diabetes on workforce productivity translates to greater throughput for the resource investment as well as optimization and retention of employee skills and expertise, especially among older workers.

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