Contextual Annotations Predict Digital Health Solution Persistence and Diabetes Outcomes

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Background and Objectives

- Digital health solutions typically help patients manage chronic diseases by leveraging structured data like blood glucose, diet, and medication adherence
- Patient-generated annotations to such data may help patients and providers make sense of trends by tracking unique concerns
- The purpose of this research was to:
  - explore how patients use annotation features
  - explore the relationship between annotations and persistent engagement as well as diabetes outcomes

Sample and Data

- Data from 3,142 patients users of BlueStar with Type 2 diabetes (50.3% women; 62.1% aged 40-63 years; 44.1% A1c ≥ 8.0)
- Users can contextualize self-management entries with structured (e.g., ‘I feel sad’) or patient-generated freetext (e.g., ‘feeling bad, groggy, can’t focus on work’) annotations
- Annotation themes related to diet, medication, biomedical readings, health symptoms, mood, sleep, and activity
- 91,551 structured notes from 1,045 (33.3%) users
- 31,422 freetext notes from 941 (29.9%) users

Results

Early Annotation Usage and Persistence

- Early usage of structured and freetext annotations associated with greater persistence
- General increasing monotonic relationship for freetext annotation usage
- Structured annotations show only significant increase in persistence in contrast to no notes

Total Annotation Usage and A1C Improvement

- Highest freetext note takers exhibiting significantly larger declines in A1C compared to all other categories of freetext annotation usage (p < .02)
- No relationship with structured annotations (p = .08)

Indicators of Patient Burden and Glucose Control

- Also investigated specific content in annotations and relationship with glucose control
- Computed a Patient Burden Annotation Index (PBAI) by summing annotations that reflected negative mood or health-related symptoms in a user’s first 14 days of use
- Patient burden associated with fewer ‘in target’ readings (p = .04), more ‘low’ readings (p = .01), and more ‘high’ readings (p = .06)

<table>
<thead>
<tr>
<th>Theme</th>
<th>Example Annotations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative Mood</td>
<td>Structured: ‘I feel stressed’, ‘I feel sad’</td>
</tr>
<tr>
<td>Health-Related Symptoms</td>
<td>Free-Text: ‘stress levels on overload right now’, ‘I get very depressed when my BG is high because I want it to stay in the proper range’</td>
</tr>
<tr>
<td></td>
<td>Structured: ‘I feel sick’, ‘I am feeling light-headed’</td>
</tr>
<tr>
<td></td>
<td>Free-Text: ‘did not check b/s. still not feeling good’, ‘not sleeping well’</td>
</tr>
</tbody>
</table>

Conclusion

- Early usage of annotations is associated with greater persistence in using a digital health solution
- High levels of annotation usage associated with greater improvements in A1C
- However, annotation content reflecting high levels of patient burden during early engagement was associated with worse glucose control

Figure 1. Screenshots of BlueStar app.

Figure 2. Trends in early annotation usage and total duration of BlueStar usage.

Figure 3. Trends in first and last measures of A1C by usage of annotations.

Figure 4. Proportion of blood glucose readings in each range by burden.

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