Symptoms and Their Temporal Distributions: An Interpretable AI Approach for Depression Detection in Social Media

Estimation of the Net Benefits

This is a rough estimation, based on the macro-level statistics we can find and a few assumptions.

(1) Estimation of the target user base. Given that the US population in 2024 is projected to reach 345 million, with 300 million social media users (Dixon 2024). Kokkodis et al. (2020) posits that 10% of online users generate posts. Therefore, the target user base in the US is estimated to be 300 million * 10% = 30 million users. According to the 2019 National Health Interview Survey (Maria and Emily, 2020), 11.5% have mild depression, while 7% of adults have more severe depression. We project that approximately 2.1 million users (30 million * 7%) experience severe depression, 3.45 million users (30 million * 11.5%) experience mild depression, and 24.45 million users (30 million * 81.5%) are considered healthy.

(2) Assumptions. We assume that users who are intervened by platforms will seek professional help, and all social media platforms in the US implement our approach.

(3) Cost and benefit estimation. The socioeconomic burden of severe depression is estimated to be $16,854 per adult annually (Greenberg et al. 2023). According to Birnbaum et al. (2010), the total cost for mild depression is approximately one-third of that for severe depression, amounting to $4,735. The negative consequence of a false positive is the cost of diagnostic testing. The estimated cost for an initial psychiatric consultation is approximately $400 (Wooldridge 2022). Based on the predictive performance of our depression detection model (Precision: 92.3%; Recall: 82.3%), we estimate the depression management costs both with and

without the use of this model. When a social media-based depression detection model is not implemented, 17.6% of mild depression cases progress to severe depression (Zhang et al. 2023). However, by utilizing our detection model, these progressions can be effectively prevented. The difference between these costs is used to calculate the net benefit of using the model. The detailed depression management cost and benefit estimations are presented in Table D1.

Table D1: Depression Management Cost and Benefit Estimation

	Annual depression management cost and benefit estimation	Explanation	Total cost
Depression management cost without our model	(1) 3.45 million (mild depression) * 82.4% (maintain) * $4,735 (cost for mild depression)	Depression management cost of users who remain mild depression	$59.06 billion
	(2) 3.45 million (mild depression) * 17.6% (progress) * $16,854 (cost for severe depression)	Depression management cost of users who progress to severe depression	
	(3) 2.1 million (severe depression) * $16,854 (cost for severe depression)	Depression management cost of users who have always had severe depression	
Depression management cost with our model	(1) 3.45 million (mild depression) * 82.4% (maintain) * $4,735 (cost for mild depression)	Depression management cost of users who remain mild depression	$53.86 billion
	(2a) 3.45 million (mild depression) * 17.6% (progress) * 81.3% (Recall) * $4,735 (cost for mild depression)	Estimation for true positives: Depression management cost of users who were to progress to severe depression, but with our model (true positive) and platforms' interventions, stayed mild depression.	
	(2b) 3.45 million (mild depression) * 17.6% (progress) * 18.7% (1 - Recall) * $16,854 (cost for severe depression)	Estimation for false negatives: Depression management cost of users who progress to severe depression. Our model did not identify them (false negative). Without intervention, they progressed to severe depression.	
	(2c) 24.45 million (healthy users) * 7.7% (1- Precision) * $400 (cost for initial diagnosis testing)	Estimation for false positives	
	(2d) $0 (No intervention)	Estimation for true negatives	
	(3) 2.1 million (severe depression) * $16,854 (cost for severe depression)	Depression management cost of users who have always had severe depression	
Net benefit of our model	$59.06 billion (Depression management cost without our model) - $53.86 billion (Depression management cost with our model) = $5.20 billion. Note: the cells highlighted in blue are the differences that our model can make.		

(4) HITL approach for cost mitigation. Integrating expert insights through the HITL approach can help mitigate both false positive and false negatives (items (2b) and (2c)). For false negative users, the depression management cost is calculated as: 3.45 million * 17.6% * 18.7% * $16,854 = $1,913.71 million. In the most optimistic case, if the number of false negatives is

reduced to zero, the cost shifts from treating severe depression to treating mild depression: 3.45 million * 17.6% * 18.7% * $4.735 = $537.64 million. The difference of $1,376.07 million represents the total addressable depression management cost that could be saved by eliminating false negatives. For false positive users, the depression management cost is calculated as: 24.45 million * 7.7% (1 - Precision) * $400 = $753.06 million, part of which could be saved by reducing false positives. When combined, the total addressable cost from reducing both false negatives and false positives amounts to $1,376.07 million + $753.06 million = $2.13 billion. If the HITL approach reduces these errors by 20%, 40%, 60%, 80%, and 100%, this would result in increased net benefit of $0.43 billion, $0.85 billion, $1.28 billion, $1.70 billion, and $2.13 billion, respectively.

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