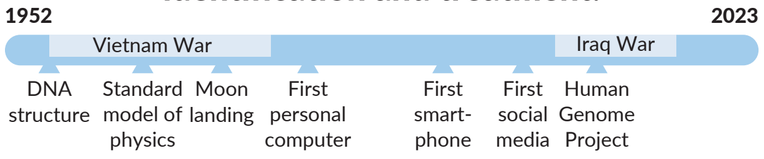
SuiSensor: A Novel, Low-Cost Machine Learning System for Real-Time Suicide Risk Identification and Treatment Optimization via Computational Linguistics

Background

The suicide crisis is troubling, to say the least:

- Suicide robs over 2000 lives daily.
- Suicide deaths have risen by more than 30% since 2000.
- Suicide-related emergency room visits have increased by 50.6% since the COVID-19 pandemic.

70 years of revolution—and the same old risk identification and treatment:



Suicide risk assessment is only 5.5% accurate:

Timing	Subjectivity	Precision

Suicidal behavior shifts from minute to minute.

Assessments are administered at monthly or yearly intervals.

Patient-side

- self-reporting
- recollecting the past

Clinician-side

PTSD schizophrenia

- amorphous measures
- no labs or scans

One-size-fits-all

Age
Race/ethnicity
Gender identity
Socioeconomic status

Patients undiagnosed, by *DSM* group (%)

Treatment identification is...

Arbitrary

DSM labels do not refer to etiology → treatment decisions are trial-and-error guesses.

1. cognitive behavioral therapy ✗
2. anti-psychotics ✗
3. anti-depressants ✗
4. ketamine ✗
5. electroconvulsive therapy ✓

Inaccessible

Evaluations are hard to get, both in the developing and developed world.

8 in 10 Americans have out-of-pocket costs over $200 for mental health care.

The Big Issue

Suicide risk assessments and treatment determination have not improved over the *past 70 years*, so current suicide risk assessments—woefully inaccurate and rigid—and inaccessible interview-based treatment appraisals have reached their limits.

Purpose

Digital phenotyping seems to fit the bill:

Writing patterns shift with emotions, thinking styles, and social concerns (Schubert, 2019).

Digital phenotyping = using data an individual generates over their day to characterize their physiology. It has been successful in diagnosing and treating:

- breast cancer (Delrieu et al., 2022)
- abnormal heart rhythms (Lee et al., 2021)
- Alzheimer's disease (Gregory et al., 2022)

This study considers two dimensions of writing:

Syntax: the arrangement of words to form phrases and sentences

- words per sentence
- 3rd person plural
- impersonal pronouns

Semantics: the tone of and meaning behind words

- fulfilled
- conversational
- authentic

Research Question

Can the syntactic and/or semantic features of an individual's writing be used to predict their suicide risk and optimal treatment modality in real-time?

Hypothesis

A patient's semantics reflect their underlying phenotype better than their syntax → a risk and treatment identifier based on semantics (Model M) would be more accurate than one based on syntax (Model X).

Design and Methodology

Participants (n=411) were administered...

Suicide Status Form-4 (SSF-4)
↓ suicide risk
↓ treatment modality

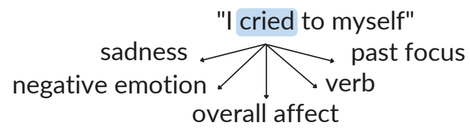
A value-free prompt asking them to recount their day

× once a week, for 6-18 weeks (until treatment worked → final modality)

5181 "events" of the SSF-4 and diary entries

Syntax and semantics were analyzed with computational linguistic software:

The **Linguistic Inquiry and Word Count (LIWC-22)** program read diary entries to crunch over 100 syntactic and semantic dimensions.



Finding associations between syntax/semantics, suicide risk, and treatment:

80% of the 5181 events (n=4170) were used to train Model X (syntax) and Model M (semantics) to identify patterns in syntax and semantics that predicted suicide risk and final treatment.

syntax → suicide risk → final treatment modality → **Model X**

semantics → suicide risk → final treatment modality → **Model M**

Testing those associations:

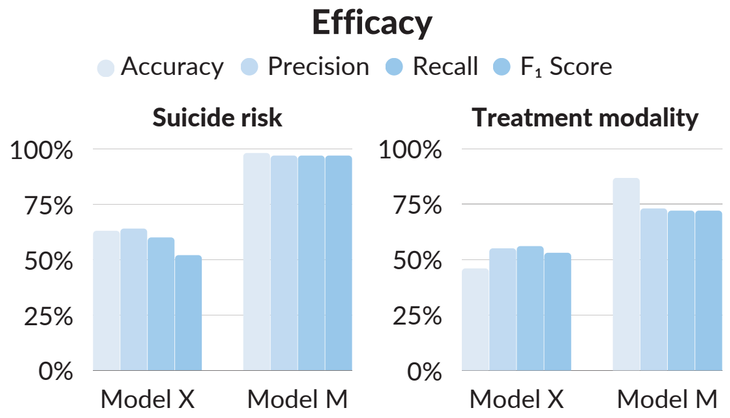
The other 20% of the events (n=1011) were used to check whether Model X and Model M could accurately predict the suicide risk and final treatment of a patient they had never seen before, based only on their syntax or semantics.

syntax → suicide risk → final treatment modality → **Model X**

semantics → suicide risk → final treatment modality → **Model M**

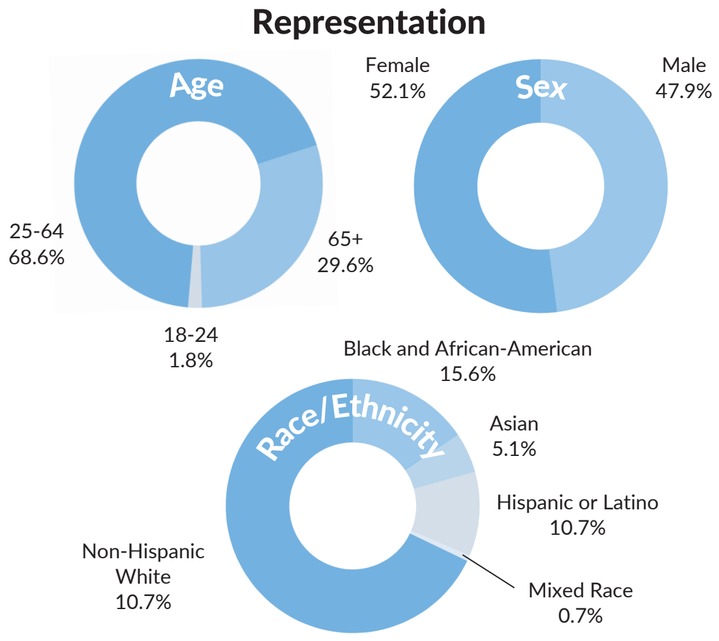
Results

Efficacy



Kruskal–Wallis test: There are significant differences ($p < .05$) in the accuracy, precision, recall, and F_1 score of suicide risk assessment between Model X and Model M.

Representation



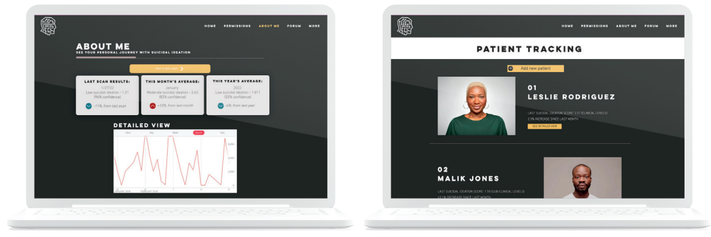
Mann-Whitney U test: The sample showed similar self-rated pain, stress, agitation, hopelessness, and self-hate metrics ($p > .05$) and distribution of suicide risks ($p > .05$) to that of Jobes et al.

Discussion

Conclusion

Model M's accuracy (98.15% for risk assessment, 87.65% for treatment determination), precision (.97, .73), recall (.97, .72), and F1 scores (.97, .72) were considerably higher than Model X's, **supporting the hypothesis**.

Model M was integrated into *SuiSensor*—a one-stop shop for clinicians:



Patient Suite

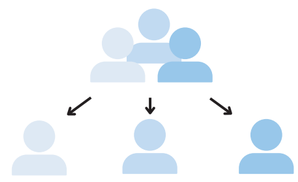
- *SuiSensor* continuously analyzes writing to provide patient risk reports, with confidence ratings, at user-selected intervals.
- *SuiSensor* recommends a local clinical evaluation at a concerning risk level.

Clinician Suite

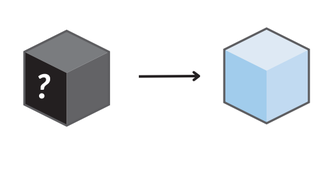
- With *SuiSensor*, clinicians can track patient risk levels and view treatment recommendations as a support tool.
- All personally identifiable information is encrypted, end-to-end.

Addressing *SuiSensor*'s limitations:

Aggregation: *SuiSensor* pooled all subjects, but sub-populations may have different relationships between writing and suicidality.



Black Box: *SuiSensor*'s predictions are untraceable, lost in the latent space of its machine learning algorithms.



Stratification: *SuiSensor*'s model will be stratified by demographic category for more accurate, customized diagnoses.

Explainable AI: *SuiSensor* will clarify its reasoning, characterize its weaknesses, and report how it will act in the future.

What's next for *SuiSensor*?

Human trials: With institutional access secured and IRB approval pending, *SuiSensor* could be in patients' and clinicians' hands as soon as 2025.

Database: The sample used in this study will be published open access for replication and similar studies.

Framework: This approach could be extended to detect and treat other under-diagnosed conditions like major depressive disorder or schizophrenia.

SuiSensor upturns risk assessment:

Timing

Moment-by-moment tracking to find and treat suicidal behavior before it is too late

Subjectivity

Crunching 73 semantic features to predict risk without biased human inputs

Precision

Centering the patient's unique context for custom predictions

SuiSensor revolutionizes treatment identification:

Delays 80.1% of patients wait months, years, or even decades to get the right treatment, but *SuiSensor* can get it right the first time.

Debts *SuiSensor* decentralizes care to happen anywhere in the world, chipping away at the annual $148 billion bill for mental health care.

Deaths Unlike the *DSM*, *SuiSensor* delivers care that aligns with a patient's etiology, addressing the underlying issues—not the symptoms.

All figures, charts, and graphs were generated by the student researcher.