

Jonas:

A Vaccine Concerns Assessment Tool

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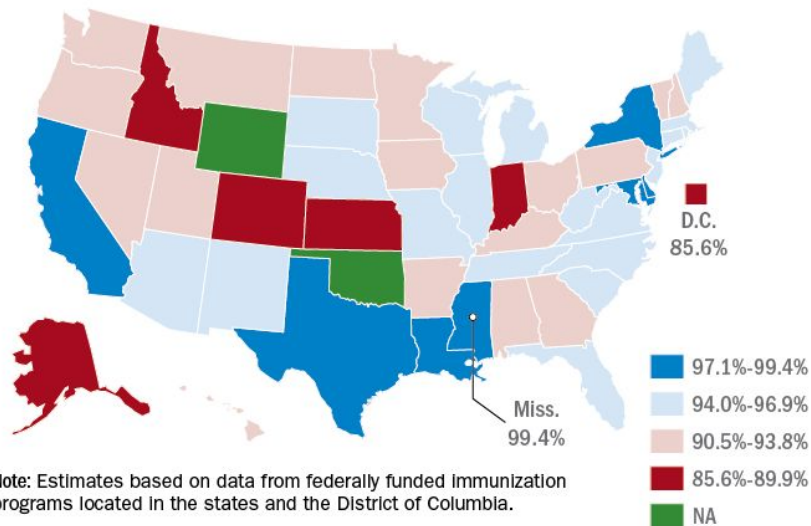
Vaccine Hesitancy & The Risks

- Vaccines can save 2 - 3 million lives per year, but vaccine hesitancy is increasing
- 2 out of 5 American adults express doubts over vaccine safety
- Increased vaccine hesitancy is related to decreased vaccine coverage
- Outbreaks are more likely if vaccine coverage is less than 95%

Vaccines save lives, but vaccine hesitancy puts lives at risk.

MEASLES, MUMPS, AND RUBELLA VACCINE

Coverage of state-required doses in kindergartners, 2016-2017



How to Combat Vaccine Hesitancy

Many effective interventions involve patients speaking with their doctors, who have the best authority to counsel them.

Doctors need support in identifying...

- Vaccine hesitant patients
- Their reasons for vaccine hesitancy

The solution needs to...

- Facilitate dialogue between doctor and patient
- Integrate with healthcare workflows

Our team has developed Jonas, named after Jonas Salk who developed one of the first polio vaccines



Product Differentiation: What Jonas Can Do

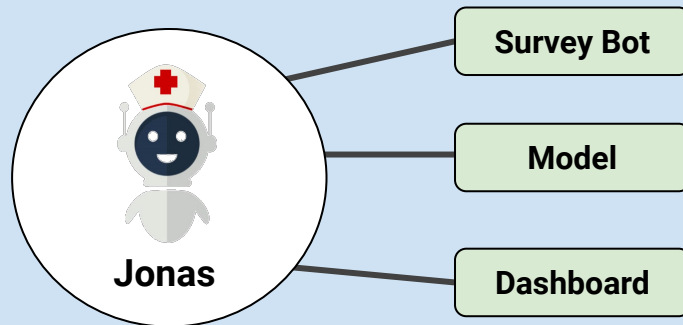
Traditional surveys are..

- Long and/or cumbersome to fill out
- Rarely used qualitatively in clinical practice
- Manually assessed

The image shows several overlapping survey forms. One form on the left asks 'Did you / your child receive...' with checkboxes for 'Yes' and 'No'. Another form in the center has a table with columns for different vaccine types and rows for various questions about their use and effectiveness. A third form on the right has a section for 'Duration of Disease' with checkboxes for 'Yes' and 'No'. The forms are dense with text and checkboxes, illustrating the complexity and length of traditional surveys.

Jonas can...

- Assess vaccine hesitancy while keeping the survey experience user-friendly
- Leverage NLP to identify hesitancy reasons
- Populate results to a provider dashboard

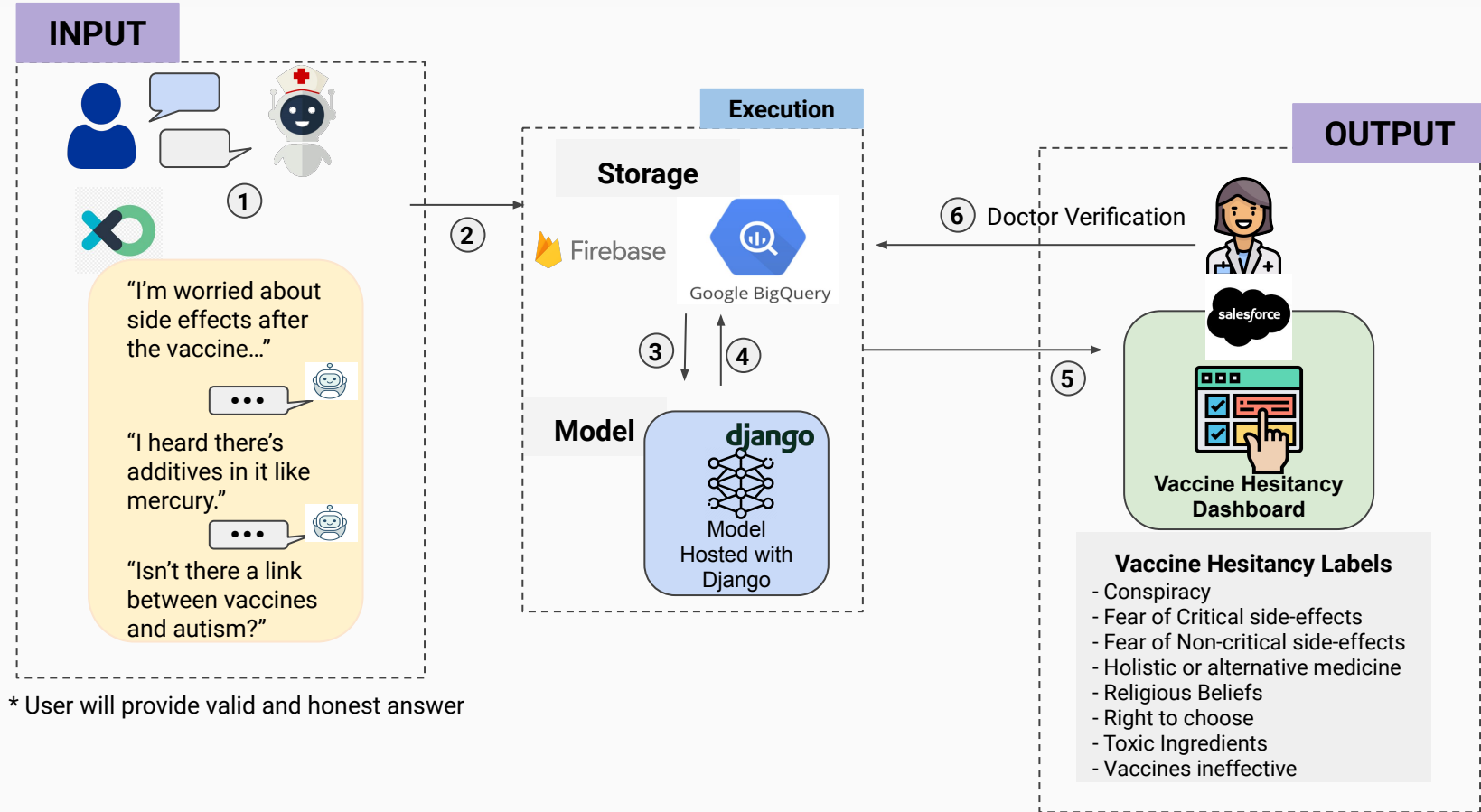




Jonas

A Vaccine Concerns Assessment Tool

Technical Approach



Part I: Data Cleansing

- Remove links, special characters
- Retain stopwords

Part II: Augmentation

- Generate synthetic and extra text samples by word embedding (GloVe) similarities.
 - See Github for [nlpaug](#)

- Original:

`"I do not have any concerns with vaccine safety. I know some people think they cause autism but that is crazy"`

- Augmented:

`"I do not people any concerns with vaccine safety . I know some people think probably problems dysfunction but that is crazy"`

Model Selection

Binary Ensemble - TFIDF

Word Order	✗
Varying Length Text	✗
Class Imbalance	✗
Multi-labels	✓

Single Layer LSTM

Word Order	✓
Varying Length Text	✓
Class Imbalance	✗
Multi-labels	✗

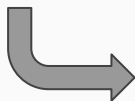
XLNET

Word Order	✓
Varying Length Text	✓
Class Imbalance	✓
Multi-labels	✓

Model

Evaluation: Model - XLNet

“Although I do believe in getting vaccinated, just for really deadly and contagious ones. You shouldn't make the decision for everyone else to get sick. You harm other people by being part of the problem. However, if there are side effects and it's like for a cold or something, I don't believe in it, just like I am on anyone's side if they decide not to get vaccinated because of their religion. I have very deep religion beliefs as well.”



Conspiracy	0
Fear of Critical	0
Fear of Non-Critical	0
Holistic/Alt Medicine	0
Logistic Concerns	0
Pro-vax	1
Religious Beliefs	1
Right to Choose	1
Toxic Ingredients	0
Vaccines Ineffective/ Unnecessary	0

Problems Encountered

- Varying text length lends to multi-labels
- Labels are also not mutually exclusive



What scoring/loss function to use?

Hamming's (edit) Distance:

The minimum number of substitutions required to change one string (vector) into the other.

Truth = [1, 0, 1, 1, 1, 0, 1]

Predicted = [1, 0, 0, 1, 0, 0, 1]

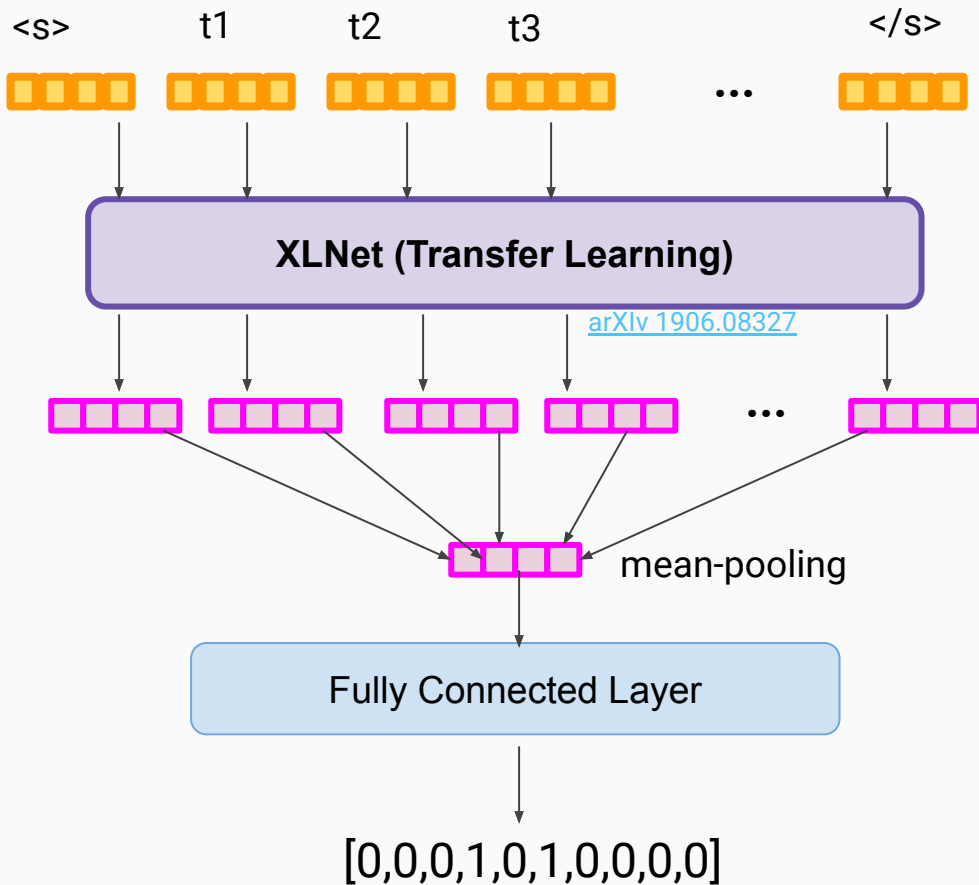
Hamming Distance = 2

(Objective: Minimize Hamming Distance to 0)

Solves:

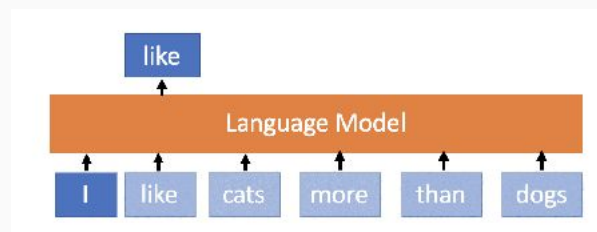
- Avoid false/over penalization as in one vs. all (binary) models.
- Reward for getting partial labels correct.
- Avoid conversion problems/having to tune for too many classes as in one vs. all (binary) models.

Evaluation: Model - XLNet

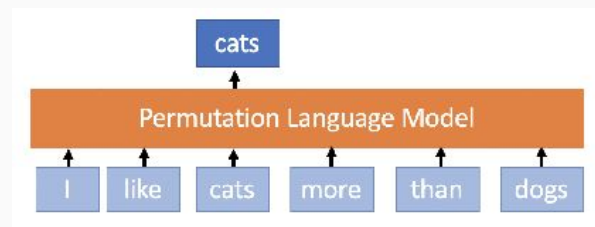


Benefits of XLNet over BERT:

- Permutation Language Modeling
 - No [MASK] token
 - Predict tokens in random order to model bidirectional dependencies.



VS



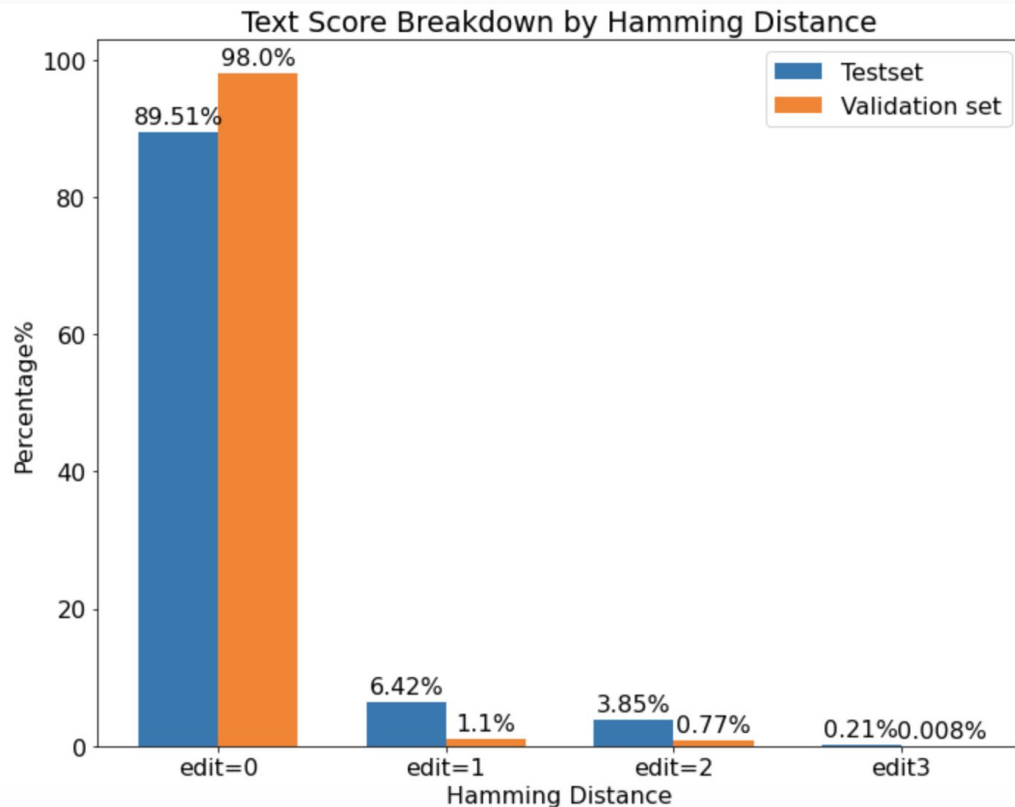
Evaluation: Model - XLNet - Error Analysis

Test set: 467 text samples

Hamming Distance	Raw Count	Percentage (%)
0	418	89.51%
1	30	6.42%
2	18	3.85%
3	1	0.21%

Validation set: 12,493 text samples

Hamming Distance	Raw Count	Percentage (%)
0	12,259	98%
1	137	1.1%
2	96	0.77%
3	1	0.008%



Evaluation: Model - XLNet - Error Analysis

What works great...

- Single sentiments (single labels)

"yes. i think they are completely fine"

- Provac

"Only my personal concerns of giving multiple medications at a single time."

- Logistic Concerns

- Multi-labeling -> catch more context

"I think for the most part vaccines are safe. They've helped to save a lot of people. On the other hand, though, I do think there are harmful side effects. I truly believe that some vaccines increase the risk of autism and other disorders in kids."

- Pro-vax
- Fear of critical side effects

What works not so great...

- Short/ambiguous text (≤ 4 words)

"I think they should"

"None, absolutely NONE!"

Surprise?

"no. but they are a necessary evil"

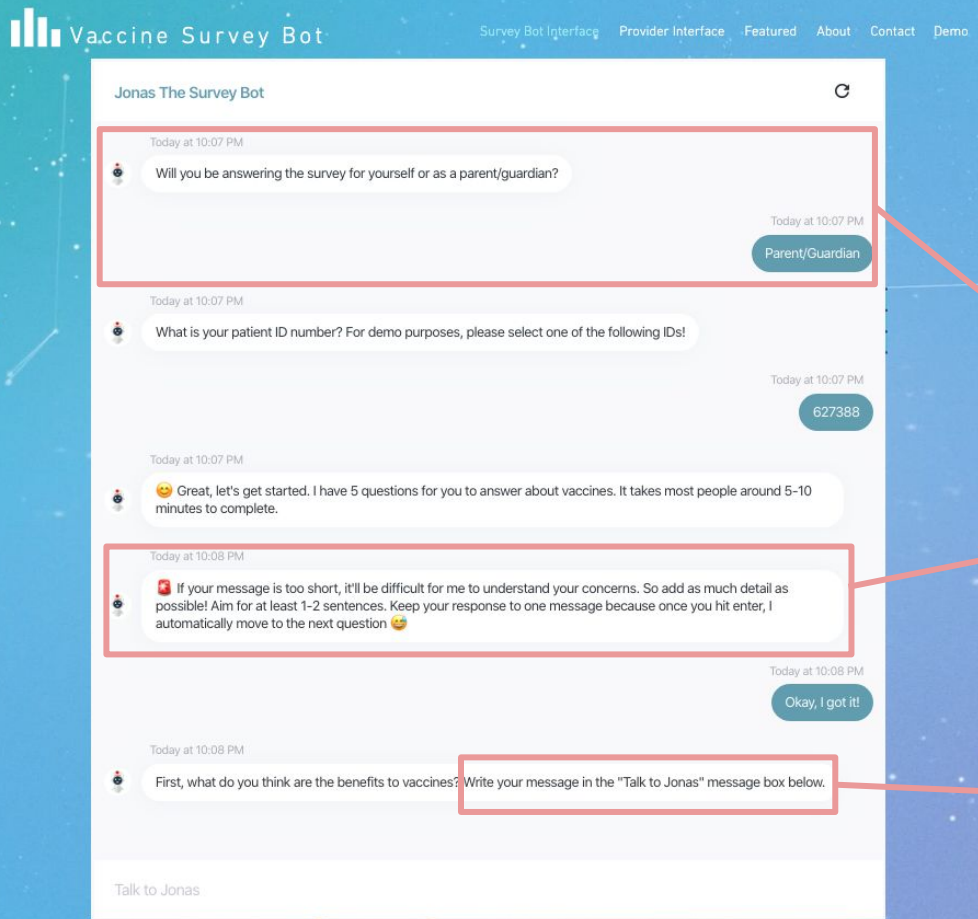
- Truth: Irrelevant

- Predicted: Vaccines are ineffective/un necessary

"I feel like it's your choice, but I would side with everyone getting vaccinated. I think it could be pretty careless not to."

- Truth: Provac
- Predicted: Provac, Right to Choose

Evaluation: Bot User Experience



Bot UX Questionnaire

- What additional feature would you have liked to see?
- What instructions were missing?
- What are your pain points?

Parent/Guardian vs Self Question

- Conditional questions will be a future direction

Longer Text requirements

- Response lengths shorter than surveys but less emotional than tweets
- Add additional features in Salesforce to highlight shorter text warning

White chat window is difficult to see

- Dark background
- Additional instructions for user to type free responses

All Search Salesforce

Jonas

Vaccination Sentiments

MIDS Clinic

26 items · Updated 3 minutes ago

CREATED DATE ↓

Jonas Assessment of Sheffie MacDunleavy - 4/12/2020	4/12/2020, 5:56 PM
Jonas Assessment of Nikos Georgeau - 4/12/2020	4/12/2020, 5:30 PM
Jonas Assessment of Antons Allcroft - 4/8/2020	4/8/2020, 1:00 AM
Jonas Assessment of Minnie Sidnall - 4/8/2020	4/8/2020, 12:37 AM
Jonas Assessment of Zack Beverley - 4/7/2020	4/7/2020, 11:13 PM
Jonas Assessment of Zack Beverley - 4/7/2020	4/7/2020, 1:21 PM
Jonas Assessment of Zack Beverley - 4/7/2020	4/7/2020, 6:05 AM
Jonas Assessment of Stan Mallinson - 4/7/2020	4/7/2020, 12:52 AM
Jonas Assessment of Antons Allcroft - 4/6/2020	4/6/2020, 9:45 AM
Jonas Assessment of Mimi Cumming - 4/6/2020	4/6/2020, 8:10 AM
Jonas Assessment of Mimi Cumming - 4/6/2020	4/6/2020, 7:52 AM
Jonas Assessment of Antons Senn - 4/6/2020	4/6/2020, 7:03 AM

Zack Beverly

Marylou Groneway

Cris Morrieson

Sheffie MacDunleavy

Sheffie MacDunleavyJonas Assessment of Sheffie MacDunleavy - 4/12/2020

Vaccination SentimentJonas Assessment of Sheffie MacDunleavy - 4/12/2020New Note

Patient NamePatient IDOrganizationPatient is Pro-VaccinationResponse for Self or As Parent/GuardianParent/Guardian

Sheffie MacDunleavy309784MIDS Clinic

Jonas Bot TranscriptSystem Information

Short Response WarningWarning DetailsResponse Length SummaryJonas has detected responses that are too short for sentiment detection in the following questions:

Question 1: Vaccination Benefits

Question 1 - Vaccination BenefitsQuestion 2 - Vaccination Safety ConcernsQuestion 3 - Should Vaccinations be MandatoryQuestion 4 - Government/Organizations MotivationQuestion 5 - Obstacles to Vaccination

Notes (0)

Vaccination Sentiment Summary from JonasVACCINATION SENTIMENT SUMMARYHESITANCY REASONS INCLUDE:

- Vaccines are a Conspiracy
- Fear of Toxic Ingredients
- Right to Choose
- Logistic Concerns
- Fear of Critical Side-Effects

Provider Sign OffMD RNMD Electronic Signature RNElectronic SignatureTest DoctorRNCredentialsVE187832987Signature Date4/12/2020Signature Date

Instructions for Providing FeedbackIn order to help us improve the performance and user experience of Jonas, we would appreciate if you could provide any additional feedback prior to your sign off. If you feel the hesitancy reasons predicted by Jonas are incorrect, please input the correct reasons to the right most columnFeedback for Jonaspatient also believes that vaccines are ineffective and unnecessary jonas did not catch thisAdditional Reasons for Vaccine Hesitancy

Verify Patient's Vaccination SentimentHesitancy Reasons InstructionsIn this column, we have pre-checked all of the reasons that your patient might be vaccine hesitant, as predicted from the conversation with Jonas. However, if you feel that the reasons are incorrect, please check all that apply to help improve the performance of our bot. If there are reasons not listed here, please also specify any additional hesitancy reasons in the text box belowPatient is Pro-VaccinationVaccines are a ConspiracyReligious Beliefs Preclude VaccinationsFear of Toxic IngredientsVaccines are Ineffective or UnnecessaryHolistic or Alternative MedicineRight to ChooseLogistic ConcernsFear of Non-Critical Side EffectsFear of Critical Side EffectsAdditional Reasons for Vaccine Hesitancy

Evaluation: Provider User Experience

MIDS Clinic

26 items · Updated 3 minutes ago

Search this list...

CREATED DATE ↓

- Jonas Assessment of Sheffield MacDunleavy - 4/12/2020
4/12/2020, 5:56 PM
- Jonas Assessment of Nikos Georgeau - 4/12/2020
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- Jonas Assessment of Antons Senn - 4/6/2020
4/6/2020, 7:03 AM

Vaccination Sentiment

Jonas Assessment of Sheffield MacDunleavy - 4/12/2020

Patient Name: [Sheffield MacDunleavy](#) Patient ID: 309784 Organization: [MIDS Clinic](#) Patient is Pro-Vaccination: ☒ Response for Self or As Parent/Guardian: Parent/Guardian

Jonas Bot Transcript

Short Response Warning

Warning Details

Response Length Summary

⚠ Jonas has detected responses that are too short for sentiment detection in the following questions:

Question 1: Vaccination Benefits

> Question 1 - Vaccination Benefits

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> Question 5 - Obstacles to Vaccination

Vaccination Sentiment Summary from Jonas

Vaccination Sentiment Summary

HESITANCY REASONS INCLUDE:

- Vaccines are a Conspiracy
- Fear of Toxic Ingredients
- Right to Choose
- Logistic Concerns
- Fear of Critical Side-Effects

Verify Patient's Vaccination Sentiment

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Patient is Pro-Vaccination ☒

Vaccines are a Conspiracy ☒

Religious Beliefs Preclude Vaccinations ☐

Fear of Toxic Ingredients ☒

Vaccines are Ineffective or Unnecessary ☒

Holistic or Alternative Medicine ☐

Right to Choose ☒

Logistic Concerns ☒

Fear of Non-Critical Side Effects ☐

Fear of Critical Side Effects ☒

Additional Reasons for Vaccine Hesitancy

Provider Sign Off

MD <input checked="" type="checkbox"/>	RN <input type="checkbox"/>
MD Electronic Signature <input checked="" type="checkbox"/> Test Doctor	RN Electronic Signature <input checked="" type="checkbox"/>
MD Credentials <input checked="" type="checkbox"/> VE187832987	RN Credentials <input checked="" type="checkbox"/>
MD Signature Date <input checked="" type="checkbox"/> 4/12/2020	RN Signature Date <input checked="" type="checkbox"/>

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Feedback for Jonas ☒

patient also believes that vaccines are ineffective and unnecessary. jonas did not catch this

Notes (0)

Evaluation: Provider User Experience

All

Jonas

Vaccination Sentiments

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Marylou Groneway

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MIDS Clinic

26 items - Updated 3 minutes ago

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Vaccination Sentiment
Jonas Assessment of Sheffie MacDunleavy - 4/12/2020

Patient Name

Sheffie MacDunleavy

Patient ID

309784

Organization

MIDS Clinic

Patient is Pro-Vaccination

☒

Response for Self or As Parent/Guardian

Parent/Guardian

Jonas Bot Transcript

System Information

Short Response Warning

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Notes (0)

Vaccination Sentiment Summary from Jonas

Vaccination Sentiment Summary
HESITANCY REASONS INCLUDE:

- Vaccines are a Conspiracy
- Fear of Toxic Ingredients
- Right to Choose
- Logistic Concerns
- Fear of Critical Side-Effects

Provider Sign Off

MD ¹	RN ¹
<input checked="" type="checkbox"/>	<input type="checkbox"/>
MD Electronic Signature ¹	RN Electronic Signature ¹
Test Doctor	
MD Credentials ¹	RN Credentials ¹
VE187832987	
MD Signature Date ¹	RN Signature Date ¹
4/12/2020	

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Feedback for Jonas ¹

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Patient is Pro-Vaccination ¹

☒

Vaccines are a Conspiracy ¹

☒

Religious Beliefs Preclude Vaccinations ¹

☐

Fear of Toxic Ingredients ¹

☒

Vaccines are Ineffective or Unnecessary ¹

☒

Holistic or Alternative Medicine ¹

☐

Right to Choose ¹

☒

Logistic Concerns ¹

☒

Fear of Non-Critical Side Effects ¹

☐

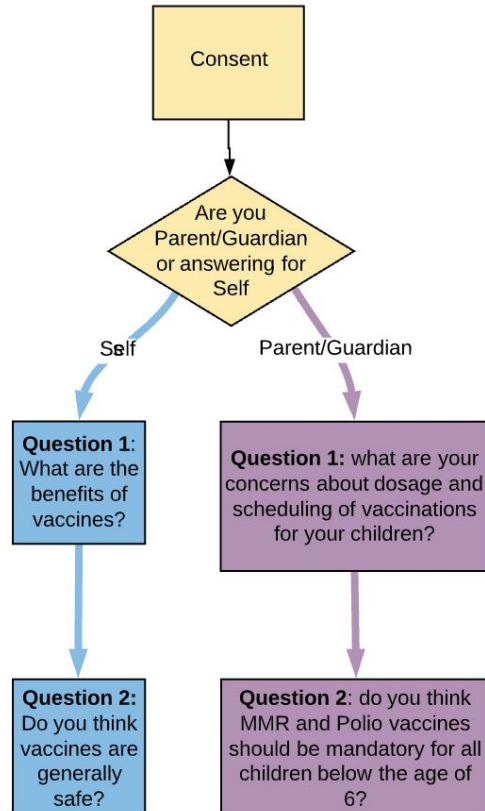
Fear of Critical Side Effects ¹

☒

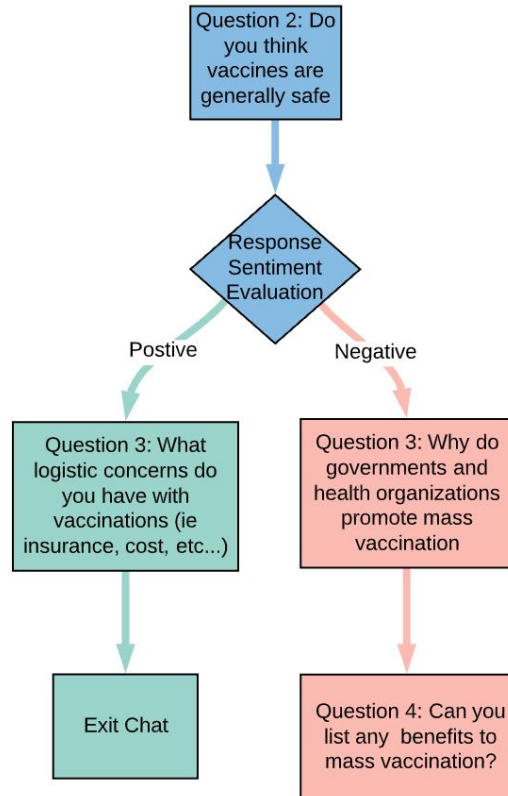
Additional Reasons for Vaccine Hesitancy ¹

Areas for Development

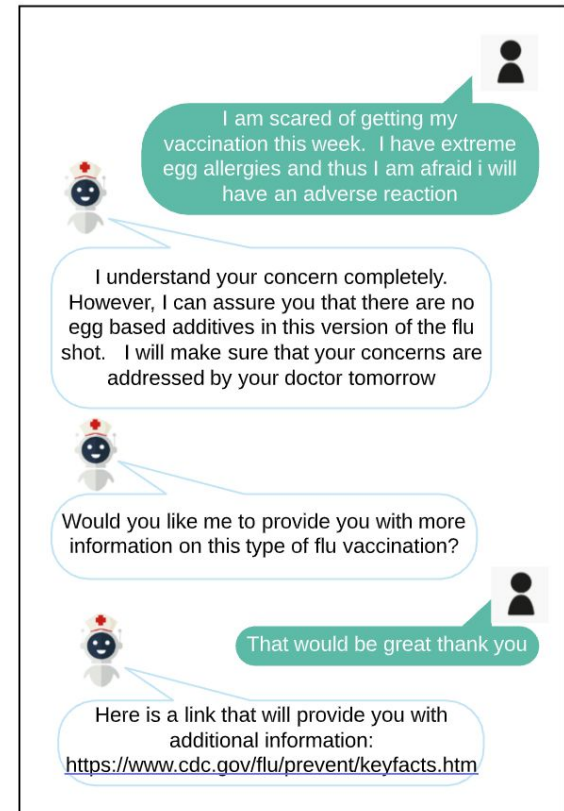
1. Parent/Guardian vs Self Flow



2. Conditional Questions



3. Bot Artificial Intelligence



Lessons Learned

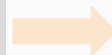
More specific labels

- Minimize "gray area" leads to mitigate bias
- Rigorous multi-labelling
- Entity extraction if more time

Assess model flexibility on text length

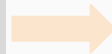
- Collect more surveys
- Collect more bot transcripts

My feeling is that vaccines shouldn't be required by government. I prefer the body should fight the virus on its own. Fatal virus' should be vaccinated against



- ✓ Right to Choose
- ✓ Provac
- ? Vaccines are Ineffective/Unnecessary
- ? Alternative or Holistic Medicine

I have heard that there are strange additives in vaccines that may have long term effects on children, such as autism and brain damage. I am concerned that certain vaccines are not fully tested. It concerns me that a vaccination puts toxic ingredients into my body.



- ✓ Fear of Toxic Ingredients - Strange Additives
- ✓ Fear of Critical Side-Effects - Autism
- ✓ Fear of Critical Side-Effects - Brain Damage

Wrap up

