

# A HARD PILL TO SWALLOW

**Understanding how medical drug reviews can help improve the healthcare system**



Christian Boothby  
2/12/2020

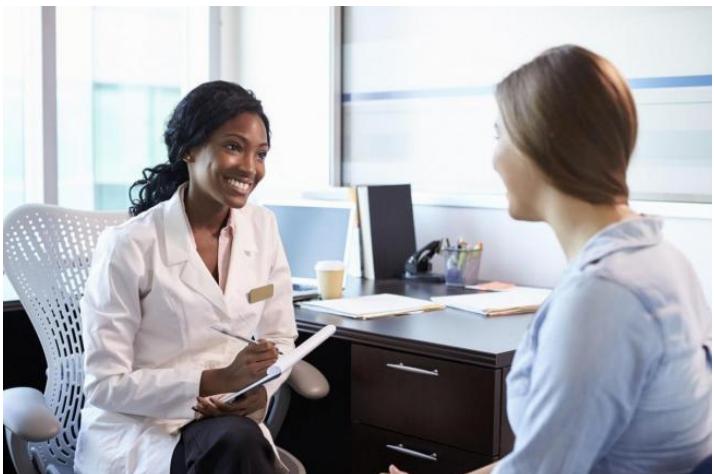
# Machine Learning and Drug Success



## Audience

I have very bad side-effects on this drug, is there an alternative?

How do I know which drug reviews to trust?



## Request

Can machine learning predict positively rated drugs?

Can it determine key elements of positive reviews?

Can it identify most common side effects of drugs?

Can it help GP's easily choose alternative upon request?

Can it help pharmaceutical companies invest in new drugs based on old drug reception?



£13.4 billion of outstanding debt

GP:Patients = 1:2087

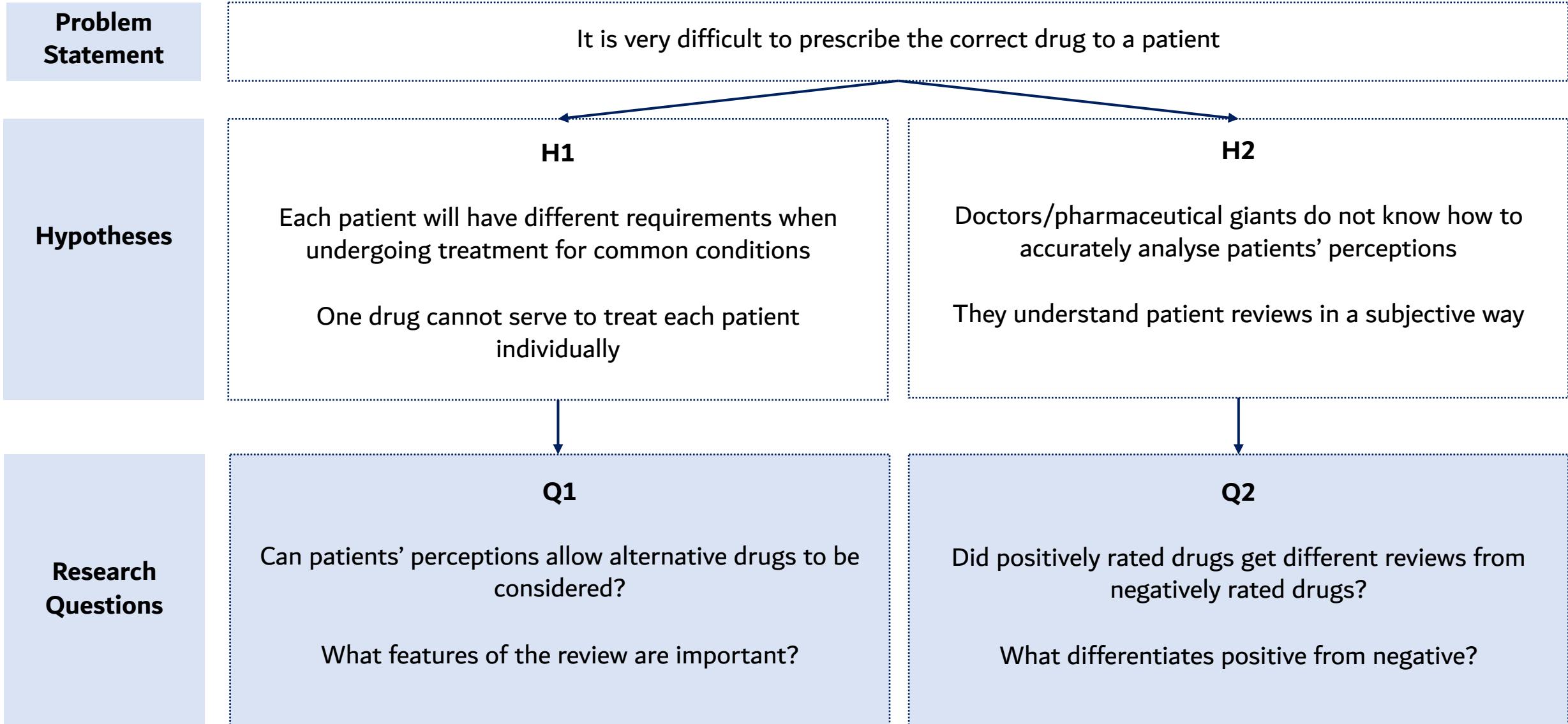


Average drug development cost :  
**£2 billion**

Average drug development time:  
**10 years**



# Problem Statement



# Plan of Action



**1. Create a dataset to answer each of the research questions**

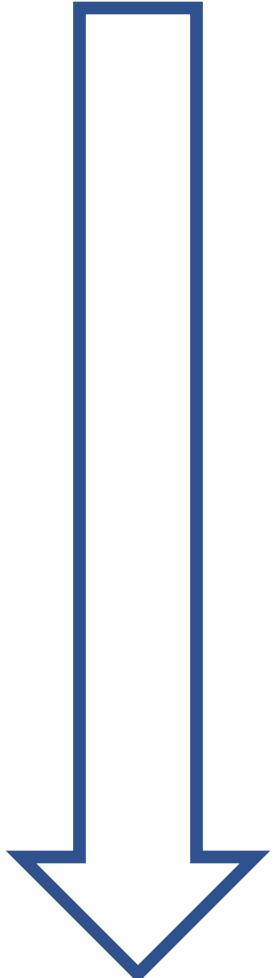
**2. Clean the dataset**

**3. Exploratory Data Analysis**

**4. Modelling**

**5. Check model performance scores and fine-tune**

**6. If model performed well, analyse results and find insights**



# Drug (Review) Dealer



Drugs.com  
Know more. Be sure.

Search All ▾  Register Sign In

Browse all medications: A B C D E F G H I J K L M N O P Q R S T U V W X Y Z 0-9 Advanced Search

DRUGS A-Z ▾ PILL IDENTIFIER INTERACTIONS CHECKER NEWS & ALERTS PRO EDITION MORE ▾

Learn Data Analytics From Experts, On Campus or Online GET INFO GENERAL ASSEMBLY

Treatment Options > Acne > Isotretinoin Print Share

### User Reviews for Isotretinoin to treat Acne

Also known as: Claravis, Amnesteem, Absorica, Zenatane, Absorica LD, Sotret Myorisan

Isotretinoin has an average rating of 8.0 out of 10 from a total of 889 ratings for the treatment of Acne. 74% of those users who reviewed Isotretinoin reported a positive effect, while 12% reported a negative effect.

Overview Side Effects Dosage Professional Interactions More ▾

Filter by condition Acne (933)

#### Isotretinoin Rating Summary

**8.0/10** AVERAGE RATING  
889 ratings from 933 user reviews

Compare all 324 medications used in the treatment of Acne.

Share your Experience Ask a Question

User Ratings

Rating	Percentage	Count
10	45%	(396)
9	21%	(190)
8	8%	(74)
7	6%	(62)
6	2%	(22)
5	4%	(38)
4	2%	(16)
3	2%	(16)
2	2%	(16)
1	8%	(73)

Reviews for Isotretinoin Sort by Most Recent

Anonymous · Taken for 1 to 6 months September 18, 2020

Accutane (isotretinoin): "I TOOK THIS POISON FOR 6 months and it completely RUINED MY HAIR FOR LIFE it changed my hair texture. I have thinning hair and it won't grow long anymore. I have an itchy sensation on scalp due to hair loss and it torments me everyday. I can't even look at myself in the mirror anymore, trust me I'd rather have acne than lose my hair. Now it's made me more insecure. YOU'RE ROLLING THE DICE BECAUSE NOT EVERYONE GETS THESE SIDE EFFECTS IF ONLY I WOULD HAVE KNOWN THIS MEDICATION COULD POTENTIALLY CAUSE BALDING I WOULD NEVER HAVE TAKEN IT."

1 / 10 Was this helpful? Yes No

Athletic Greens Ultimate Daily - Subscription

Athletic Greens Ultimate Daily is an all-in-one health drink with 75 vitamins, minerals, and whole food-sourced ingredients to help support your body's nutritional needs across...

Manufacturer Amneal Pharmaceuticals LLC

Drug Class Miscellaneous antineoplastics Miscellaneous uncategorized agents

Related Drugs doxycycline, clindamycin topical, erythromycin topical, minocycline, Tazarac

Isotretinoin Images

Tina September 5, 2020

Myorisan (isotretinoin): "This is my sixth and last month of taking isotretinoin (40mg 2x/day at 145 lbs). From angry, red acne to faded marks, this drug has transformed my face. Side effects: - dry lips - you have to CONSTANTLY have your lips covered in a layer of chapstick or vaseline (specifically for lips). Otherwise, your lips will immediately begin to peel and crack. If you're covered, you should be 100% fine. - dry

1 / 10 Was this helpful? Yes No

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1 / 10

Was this helpful? Yes No

22 · Report

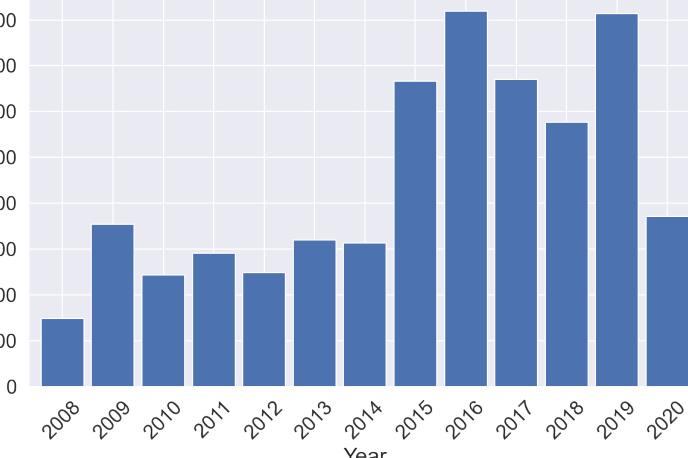
Rating	Helpful	Review	Drug	Condition	Month	Year
0	1.0	19 Accutane (isotretinoin):"I TOOK THIS POISON FO... isotretinoin	isotretinoin	Acne	September	2020

Data from 2008 to 2020 with ~58,000 reviews based on 30 common conditions

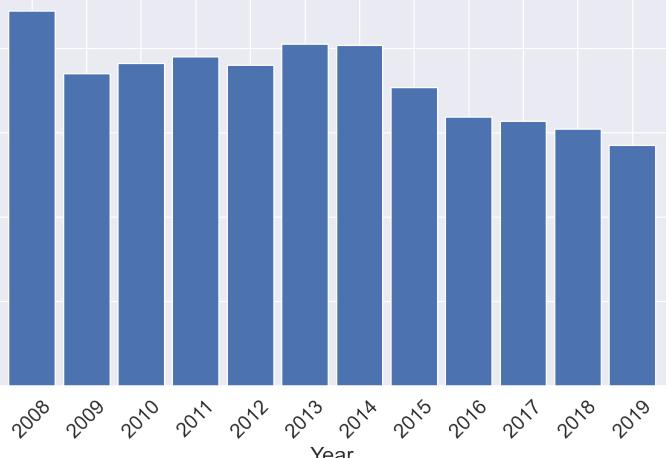
# Initial Exploratory Data Analysis



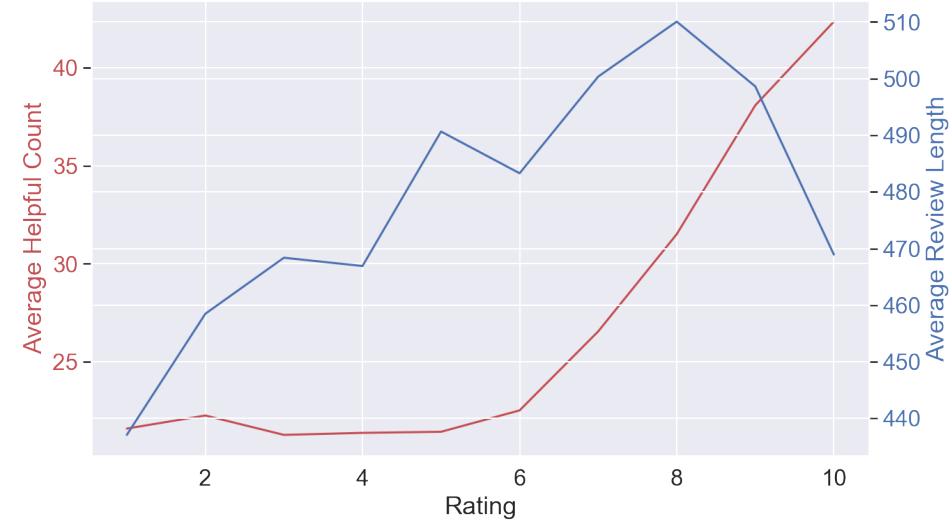
**Count per Year**



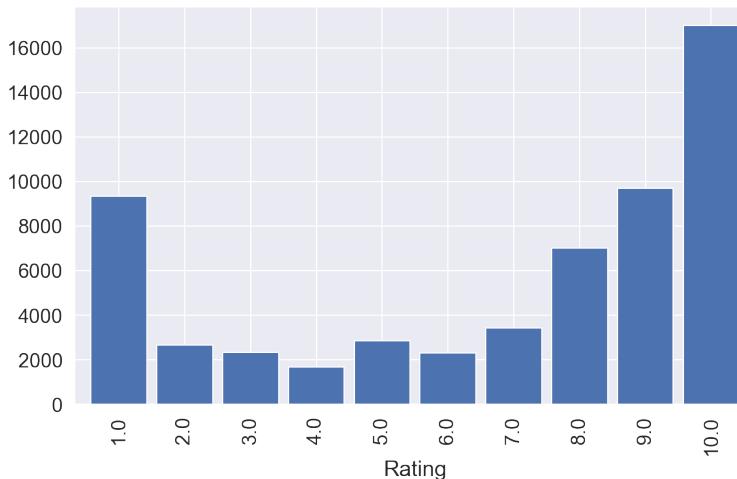
**Average Rating per Year**



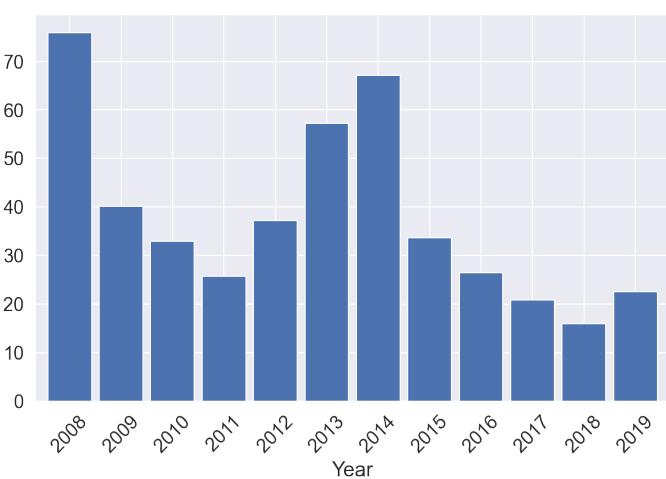
**Average Helpful Count/Review Length vs Rating**



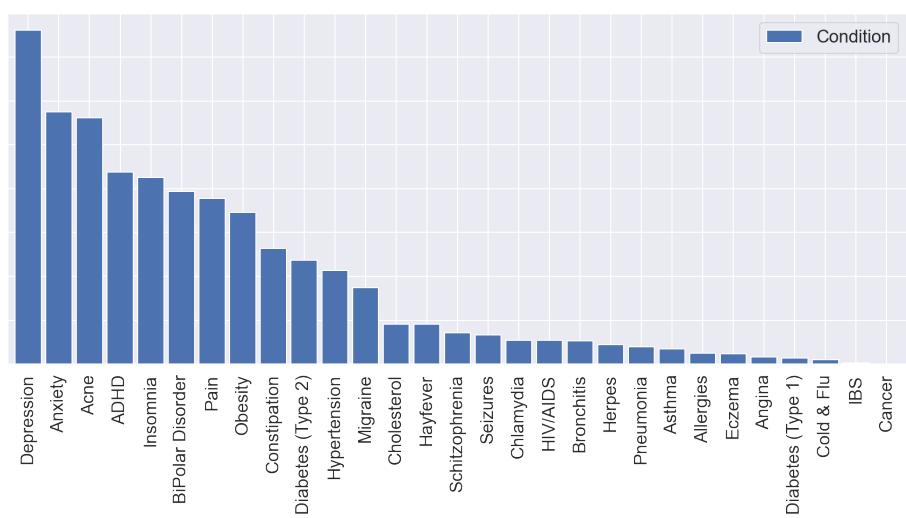
**Count per Rating**



**Helpful Count per Year**



**Count per Condition**



**Q1.**

**Can patients' perceptions allow alternative drugs to be considered?**

**What features of the review are important?**

**GA**

# Text features successfully predicted drug success



## Model Summary

### Target variable

High Rating (1) = Rating  $\geq 5$

Low Rating (0) = Rating  $< 5$

Baseline = **0.687**

Model	Model Title	Predictors	Test Score	CV Score
1	Logistic Regression (Ridge)	Helpful Count, Month, Year, Drug, Condition, Review Length	0.726	0.728
2	Logistic Regression (Ridge)	Helpful Count, Month, Year, Review Length	0.693	0.693
3	Logistic Regression	Review	0.841	0.832
4	Logistic Regression ngrams(1,2)	Review	0.876	0.867
5	Logistic Regression: ngrams(2,4)	Review	0.842	0.829

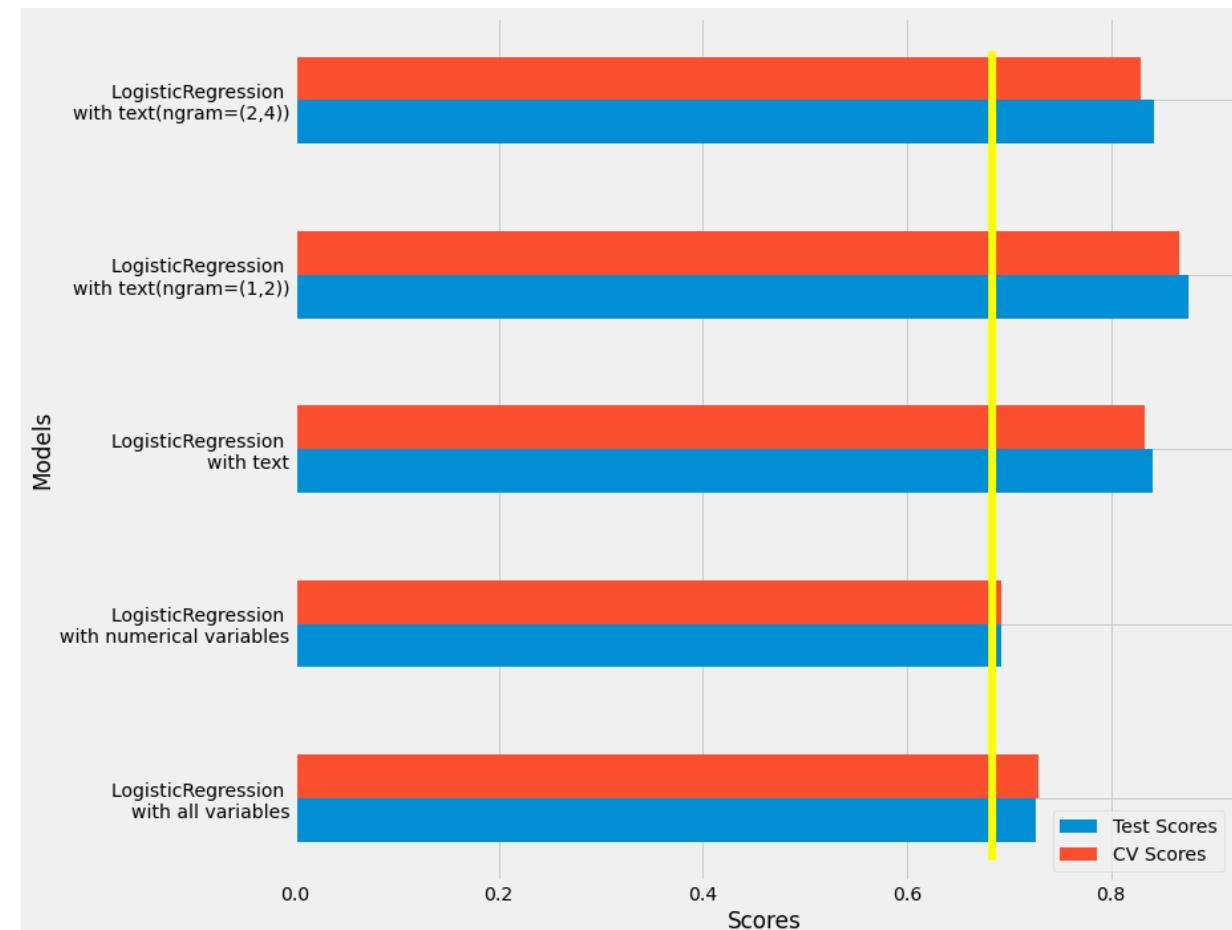
### Note:

Baseline: "Best guess if no models"

Test Score: "Model performance on unseen data"

CV Score: "How consistent the model performs"

## Results



The best predictor of drug success is 1 word or 2 consecutive words within the review text

# Fine Tune Model



## Model Summary

**Target Variable:** Binary Rating

**Predictor Variable:** Review (ngrams (1,2))

**Baseline = 0.687**

Model	Model Title	Test Score	CV Score
1	Logistic Regression: Ridge*	0.877	0.867
2	Random Forest*	0.687	0.687
3	Decision Tree*	0.701	0.698
4	SVM*	0.864	0.852
5	KNN*	0.690	0.681
6	AdaBoost*	0.780	0.779
7	GradientBoosting	0.748	0.753
8	AdaBoost + Model 1*	0.800	0.799

**Note:**

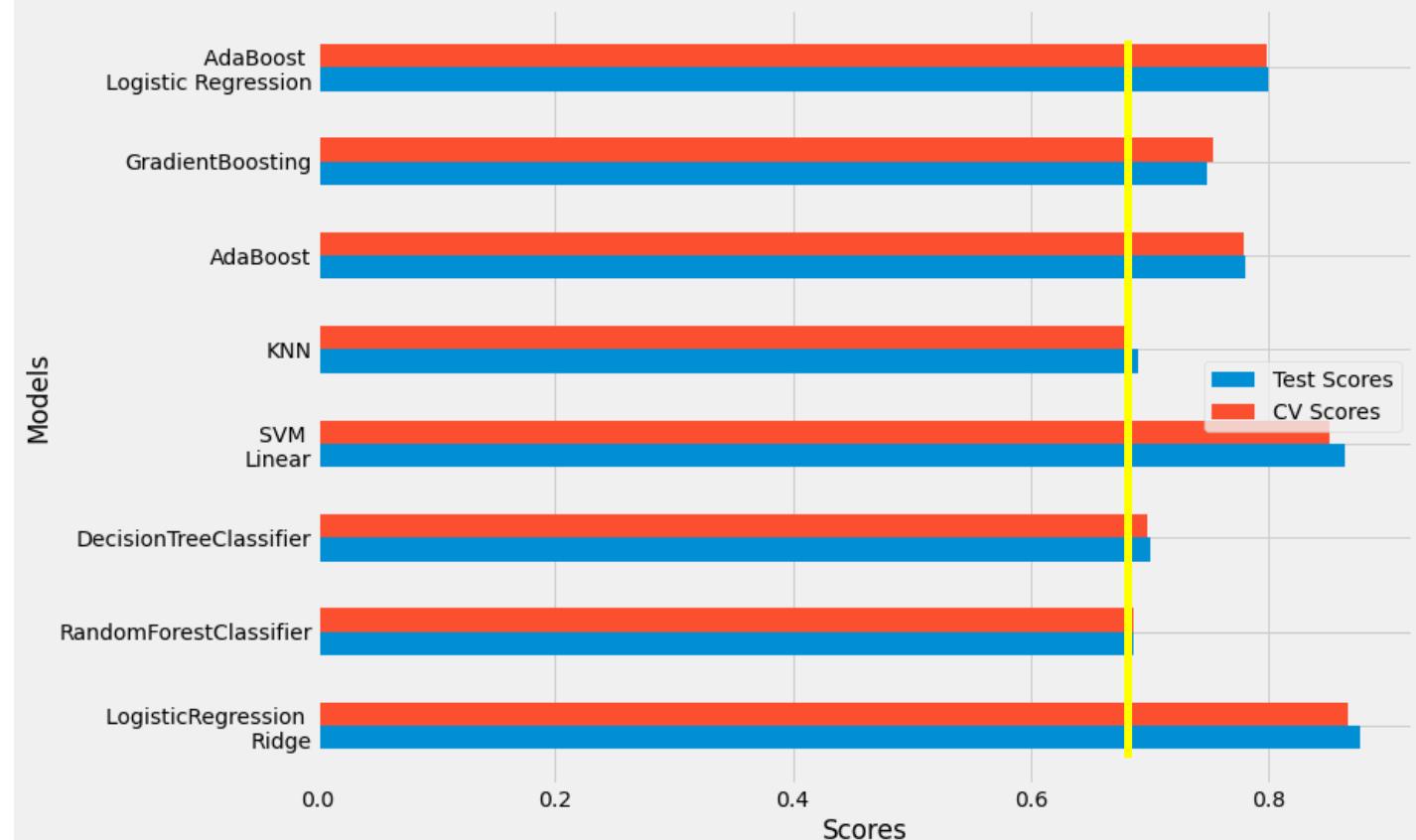
\*Result found with Grid Search

Baseline: "Best guess if no models"

Test Score: "Model performance on unseen data"

CV Score: "How consistent the model performs"

## Results



**The Logistic Regression model with Ridge penalty successfully predicted positive reviews based on the review text with 87 % accuracy (vs 69 % baseline)**

# Success Metrics

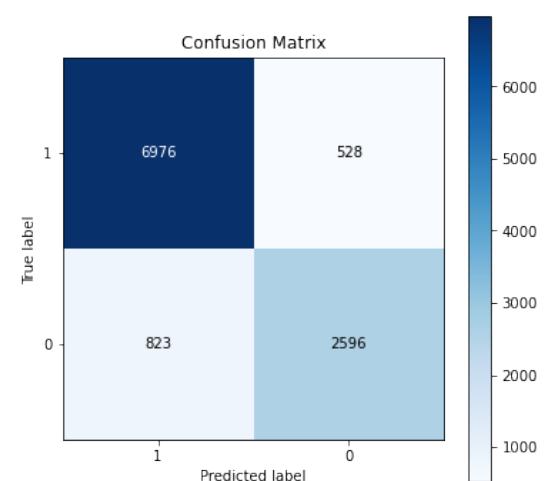


Model Title	Test Score	CV Score
Logistic Regression (Ridge)	0.877	0.867

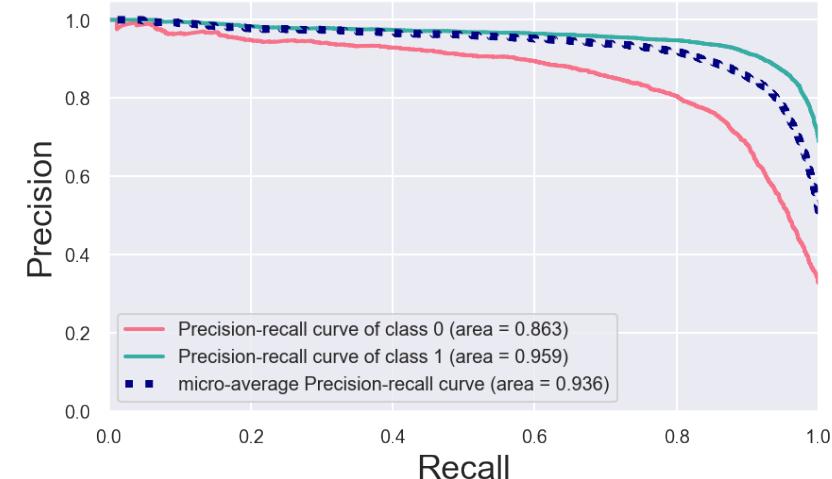
## Classification Report

	precision	recall	f1-score	support
0	0.83	0.76	0.79	3419
1	0.89	0.93	0.91	7504
accuracy			0.88	10923
macro avg	0.86	0.84	0.85	10923
weighted avg	0.87	0.88	0.87	10923

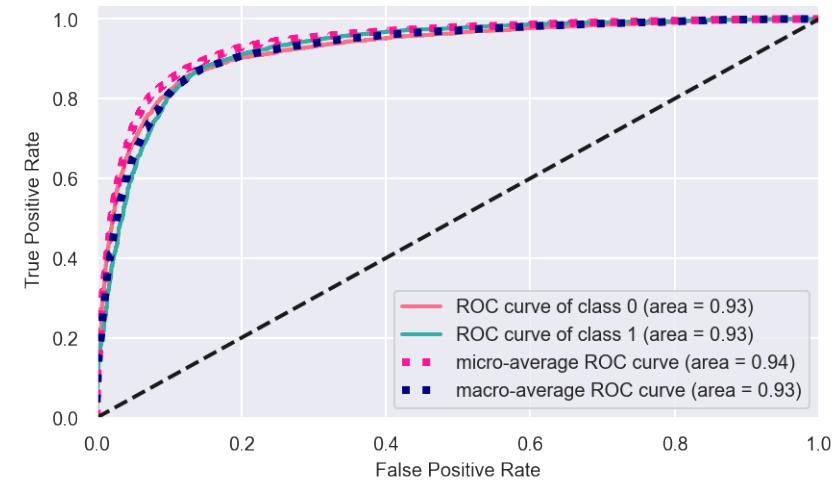
## Confusion Matrix



## Precision-Recall Curve



## ROC Curve



# Make Drug Recommendations



## Feature Engineering

1) Two large valence categories (new)

**Positiv** 1,915 words of positive outlook. (It does not contain words for yes, which has been made a separate category of 20 entries.)

**Negativ** 2,291 words of negative outlook (not including the separate category no in the sense of refusal).

We plan to develop further subcategories of these categories.

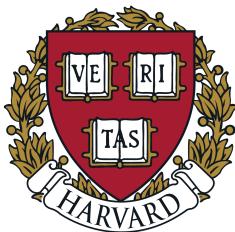
## Calculating Final Predictions

1. Count number of Positive and Negative words in each review
2. Calculate positive word ratio and transform to 1, 0.5, 0 for positive, undecided or negative respectively
3. Group by condition and calculate number of reviews per condition (denoted condition size)
4. Scale helpful votes:

$$\text{Helpful Scaled} = \frac{\text{Helpful Count}}{\text{Condition Size}}$$

5. Calculate rating predictions based on best model (Logistic Regression(ngrams(1,2)) with Ridge penalty
6. Calculate final predictions: **Final Prediction = (Model Predictions + Positive Ratio) × Helpful Scaled**
7. Group by condition and aggregate by final prediction mean for each drug

**Calculated predictions for each drug based on model predictions, number of positive words in the review and the helpful count**



## Results

Condition	Drug	total_pred mean
ADHD	adderall	0.059711
	adderall xr	0.048543
	amphetamine/dextroamphetamine	0.044772
	atomoxetine	0.046136
	concerta	0.056240
	dexmethylphenidate	0.043793
	guanfacine	0.084387
	lisdexamfetamine	0.051329
	methylphenidate	0.044478
	strattera	0.067744
	vyanse	0.050018
Acne	adapalene / benzoyl peroxide	0.011579
	benzoyl peroxide/clindamycin	0.012247
	doxycycline	0.013631
	drospirenone/ethinyl estradiol	0.011424
	epiduo	0.013570
Allergies	ethinyl estradiol/norgestimate	0.023395
	isotretinoin	0.021739
	minocycline	0.010297
	hydroxyzine	0.517520
	levocetirizine	0.151887
	xyzal	0.204644

**Q2.**

**Did positively rated drugs get different reviews from negatively rated drugs?**

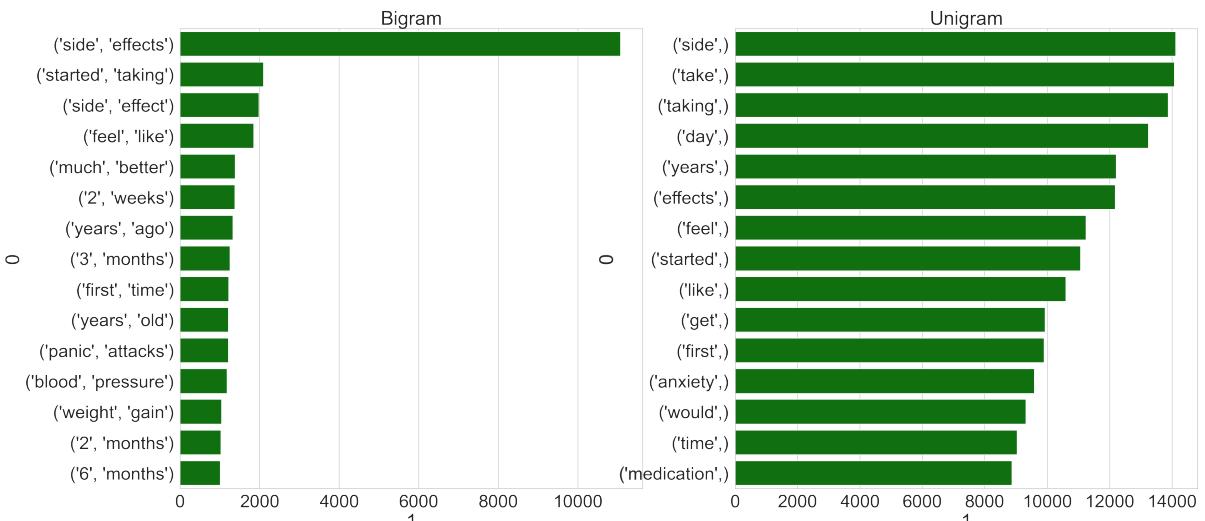
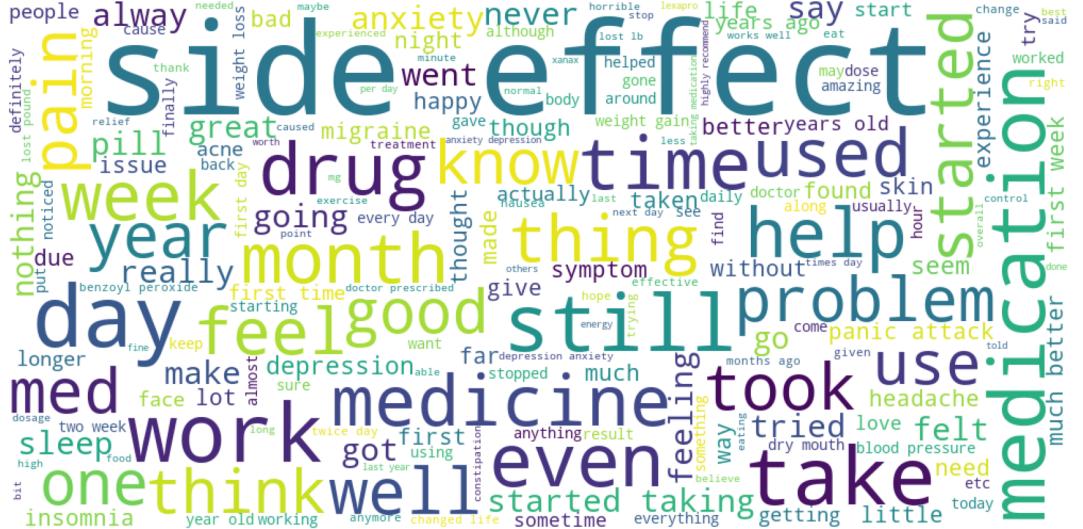
**If so, what differentiates positive from negative?**

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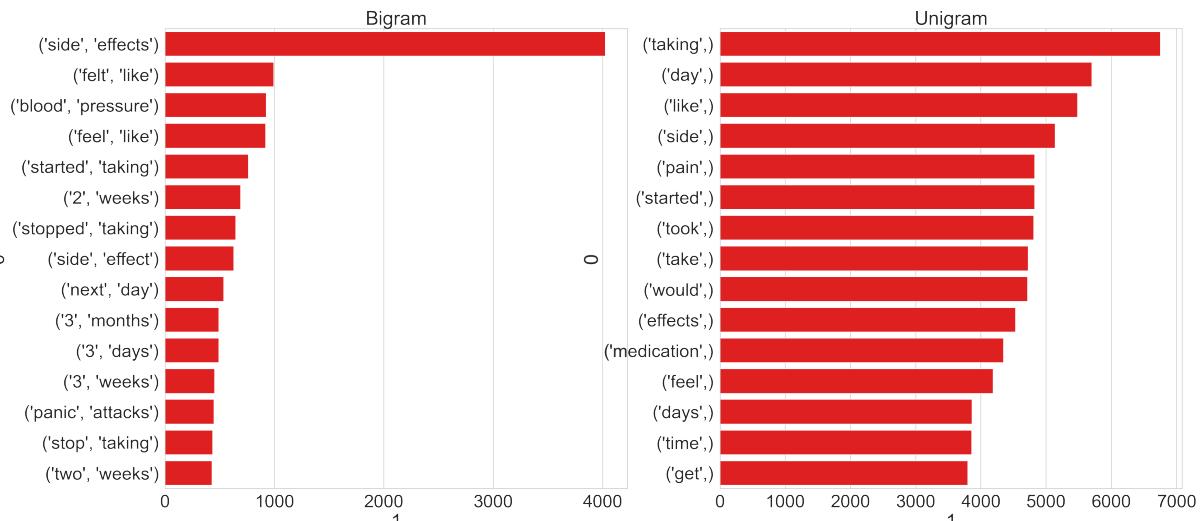
# Positive & Negative Word Count

The logo consists of the letters "GA" in white, bold, sans-serif font, centered within a red circular background.

# Positive Reviews



## Negative Reviews



# Side Effects

## Model Summary

**Target Variable:** Binary Rating

**Predictor Variable:** Side-Effects

**Baseline = 0.687**

```
['diarrhea', 'constipation', 'dizziness', 'drowsiness', 'fatigue',
'palpitations', 'nausea', 'vomitting', 'rash', 'upset stomach', 'hives',
'headache', 'weight gain', 'weight loss', 'dry', 'suicidal', 'fever',
'swelling', 'alopecia', 'heartburn', 'burning', 'dryness', 'vomitting',
'pain', 'anxiety', 'suicide', 'mood swings']
```

Model	Model Title	Test Score	CV Score
1	Logistic Regression: Ridge*	0.693	0.693
2	Random Forest*	0.689	0.694
3	Decision Tree*	0.690	0.694
5	SVM*	0.647	0.648
4	KNN*	0.672	0.669

**Note:**

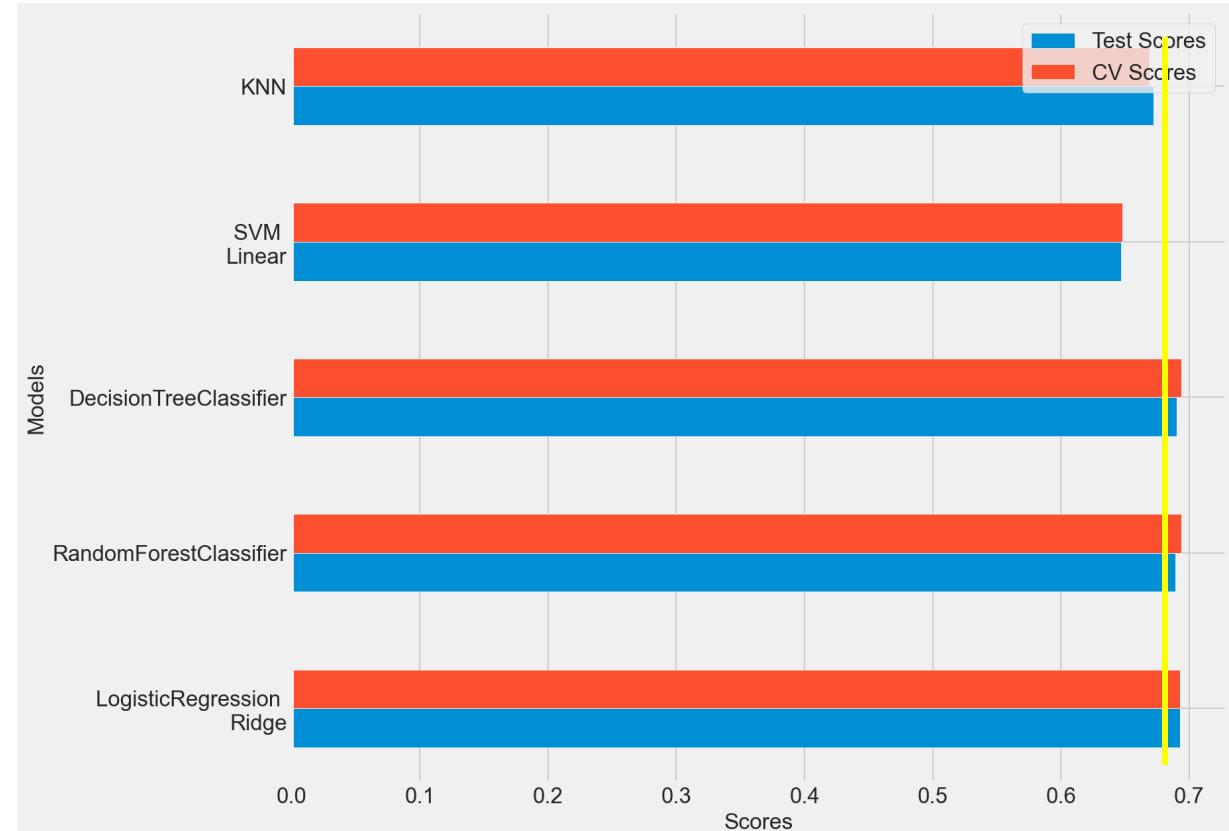
\*Result found with Grid Search

Baseline: "Best guess if no models"

Test Score: "Model performance on unseen data"

CV Score: "How consistent the model performs"

## Results

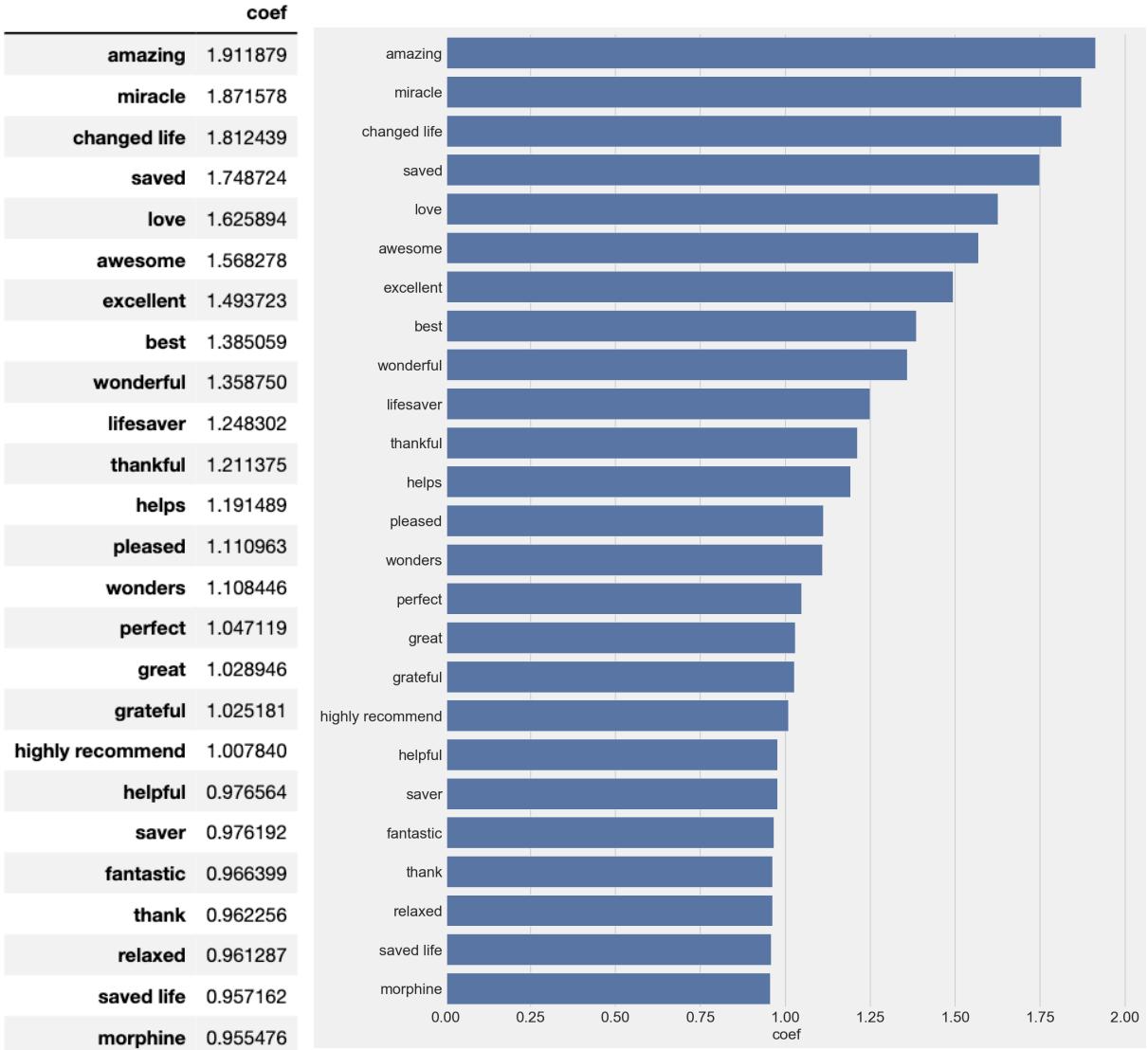


Mention of side effects in the review failed to predict positive drug ratings with accuracy above the baseline (0.687)

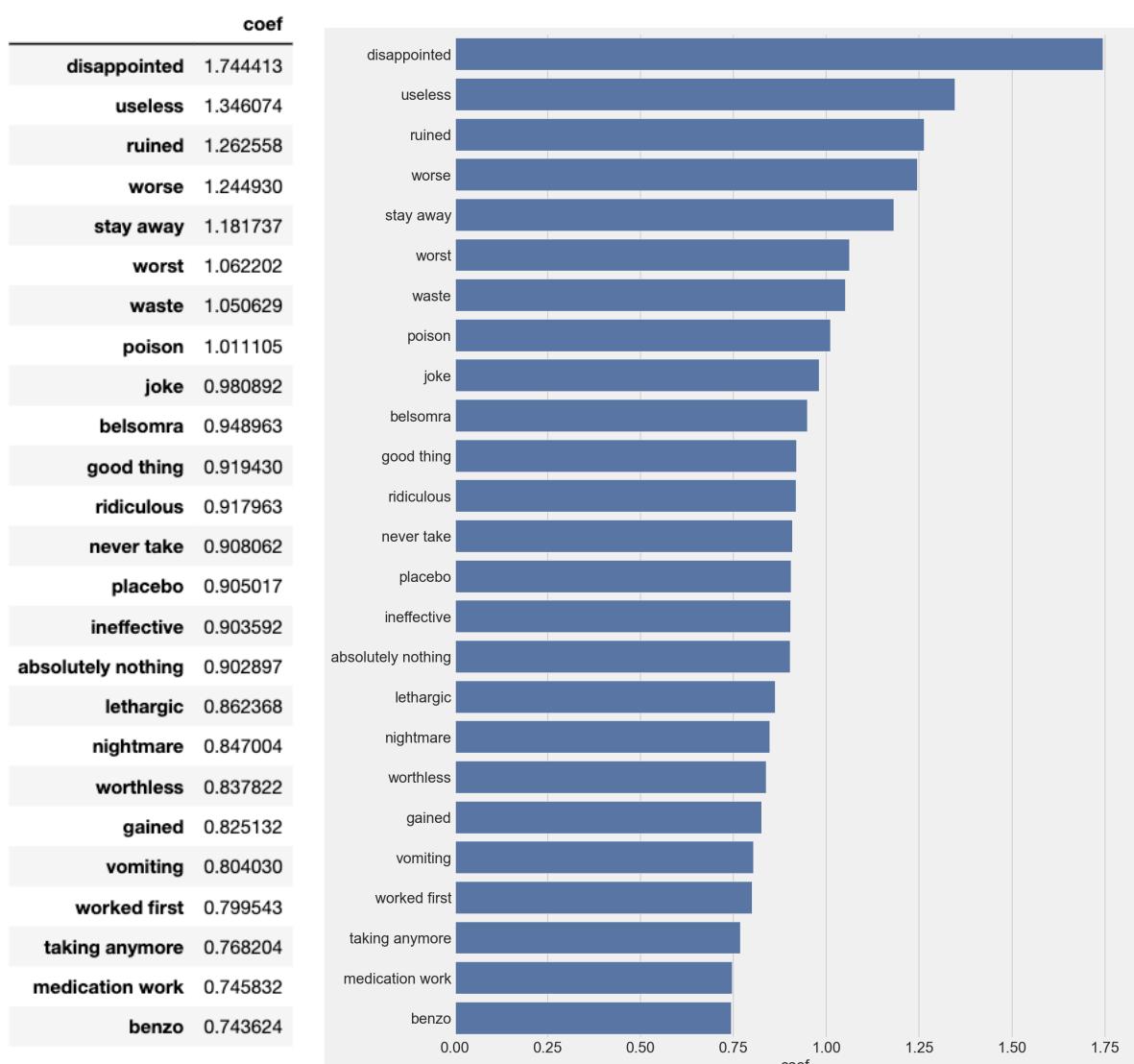
# Positive & Negative Coefficients



**Positive Reviews**



**Negative Reviews**



# Review Features

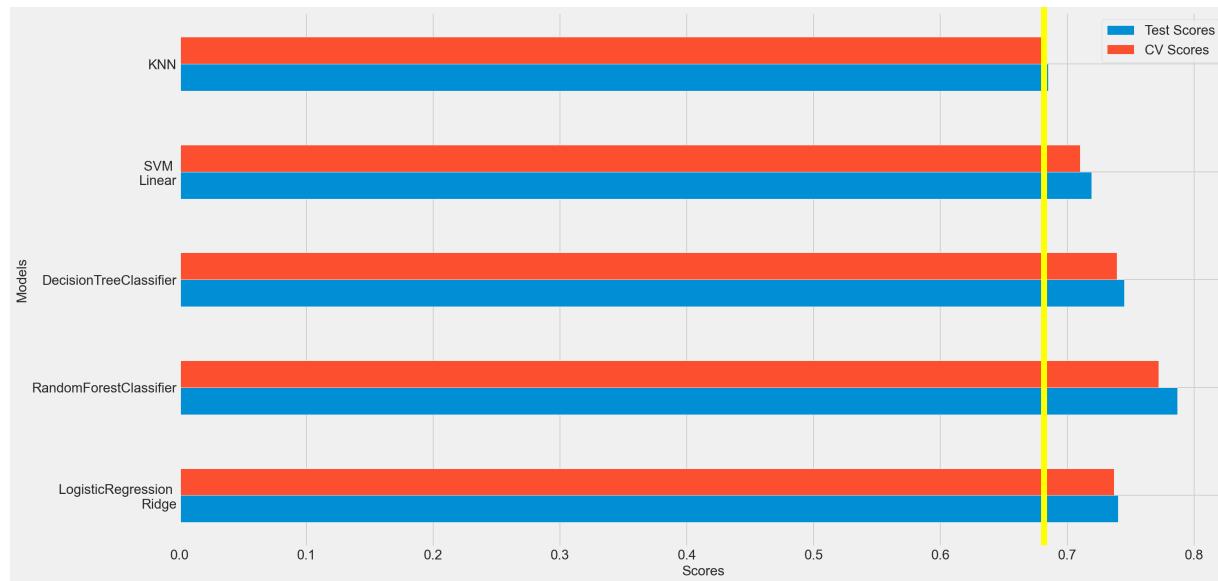


## Model Summary

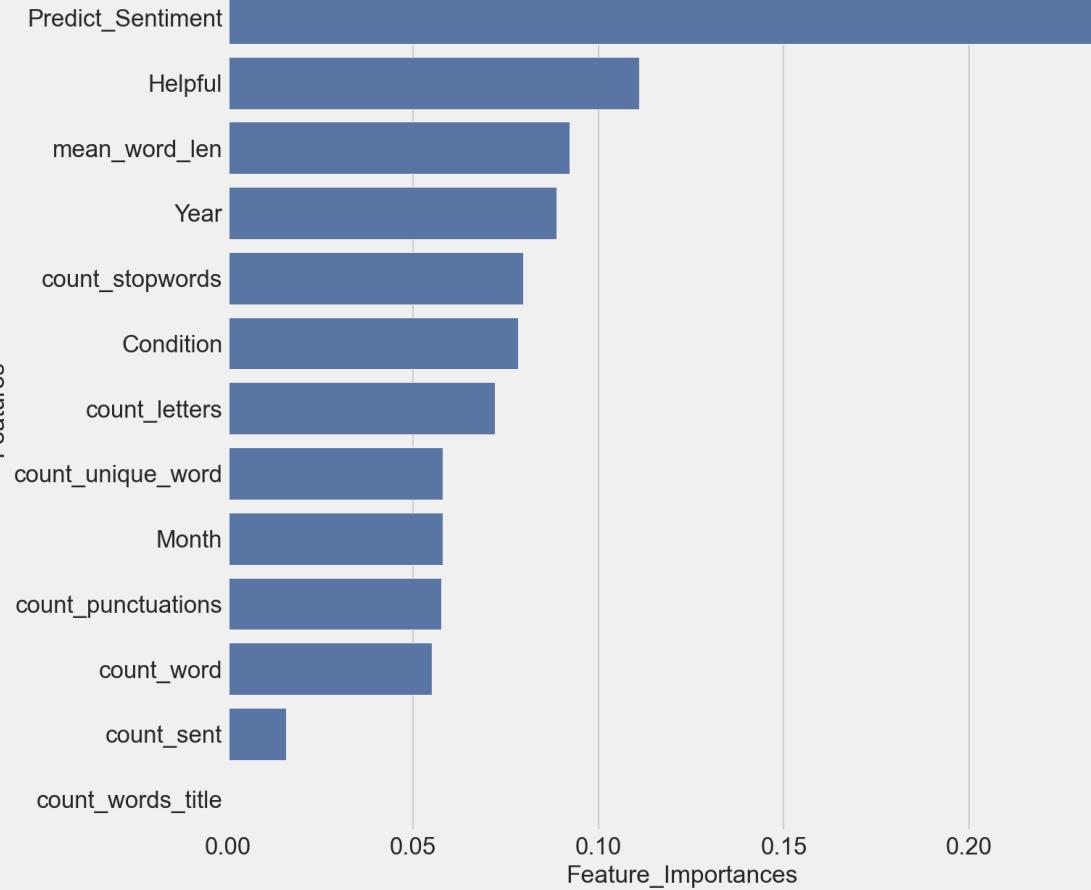
**Target Variable:** Binary Rating

**Predictor Variable:** Review features, Helpful, Month, Year, Condition

Model	Model Title	Test Score	CV Score
1	Logistic Regression: Ridge*	0.740	0.737
2	Random Forest*	0.787*	0.772
3	Decision Tree*	0.745*	0.739
4	SVM*	0.719	0.710
5	KNN*	0.685	0.683



## Results



**Sentiment has the most importance as a predictor variable for positive ratings (with Random Forest Model)**

# Conclusion

GA

# Suggestions for Drug Success



## Research Question 1

- Classification models managed to:
  - Predict drug success with **87.6%** accuracy (vs. baseline 68.7%)
  - Using the **review (ngrams(1,2))** as the predictor variable
  - Using **Logistic Regression with Ridge penalty**
- Can form recommendations based on the model predictions, positive word ratio and helpful count
- Based on these results, there should be more focus on **patient perception** than drug attributes

## Research Question 2

- Positive and Negative Reviews had similar word counts but our model from Q1 gave feature importance's for each review type
- The mention of side effects in the reviews did not predict drug success
- Classification models managed to:
  - Predict drug success with **78.7%** accuracy (vs. baseline 68.7%)
  - Using the **review features** as the predictor variables
  - Using **Random Forest Classifier**
- Based on the results of sentimental analysis, there should be more focus on **review sentiment** than other drug attributes

# Research Limitations and Future Recommendation



## Research Limitations

- No **location** information is given on the reviews, so it is unknown as to where the patient is receiving the treatment
- Only looked at limited amount of conditions and drugs due to **time constraints** with web-scraping
- Sentiment analysis has **low reliability** – set a limit on sentiment words and exclude below
- Helpful count can be higher for older reviews due to **number of cumulated site visitors increasing**

## Future Recommendations

- Obtain **more information** from drugs.com or other websites to ensure more accurate results
- Include more columns such as **dosage, interactions with other drugs, known drug side-effects**
- **FIT MORE MODELS**
- Build **recommendation engines**
- AWS

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