

Automatically Identifying Comparator Groups on Twitter for Digital Epidemiology of Pregnancy Outcomes

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Birth Defects are Common, Costly, and Critical

Birth defects are common



Every 4½ minutes, a baby is born with a birth defect in the United States.

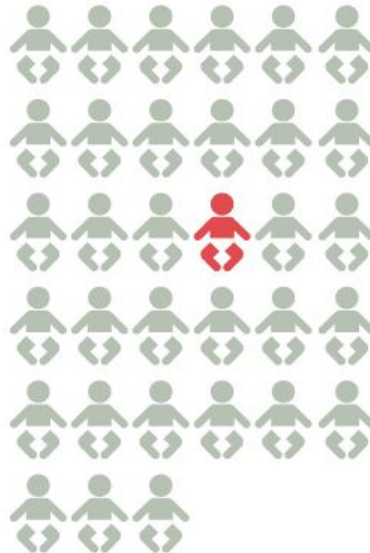
Birth defects affect

1 in every **33**

babies born in the United States *each* year.

That translates into about

120,000 babies.



Birth defects are costly



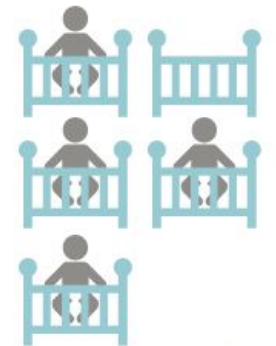
Each year, total hospital costs for U.S. children and adults with birth defects *exceed* **\$2.6 billion**, not including outpatient care or many provider charges.

Birth defects are critical

Birth defects cause

1 in every **5**

deaths during the *first year* of life.



Related Work

Builds on recent HLP studies that involve:

1. Discovering large cohorts of pregnant women on social media (Sarker et al)
2. Identifying a cohort of women with pregnancies that led to birth defect outcomes on Twitter (Klein et al)
3. Using birth defect cohort to examine medication use during pregnancy (Golder et al)

Identifying a Comparator group

- Past studies used a control group that:
 - Was limited in size
 - Could not account for adverse pregnancy outcomes
 - Contained users that may or may not have given birth
 - Did not specify if pregnancy reached term

Study Aim

“To advance the use of social media for observational studies of pregnancy outcomes by developing a natural language processing (NLP) pipeline for automatically identifying users from which to select comparator groups on Twitter”



Study Design

- Aims to create a comparator group for further research on pregnancy outcomes
- Controls for miscarriage, stillbirth, preterm birth, or low birthweight
- Enables the use of data from publicly available tweets/timelines in supplementing research
- Reduces sizable manual annotation effort required to create control group (over 800 hours)

TP plus NB

Control Group Criteria

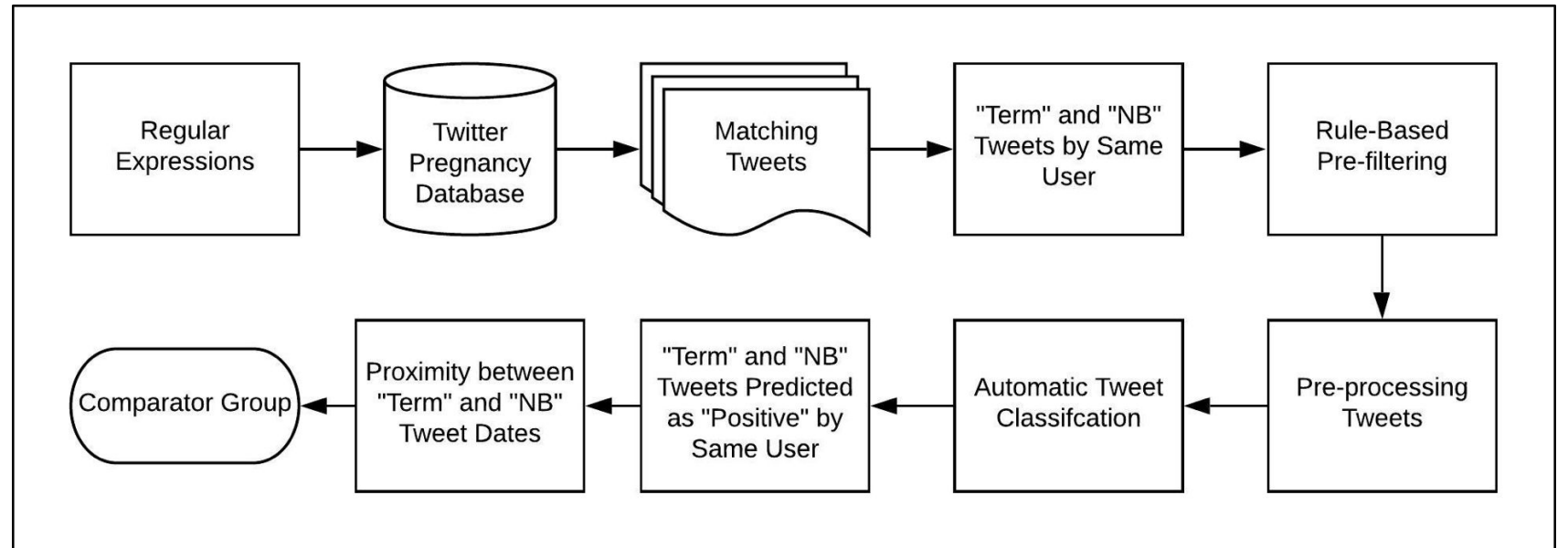
Term Pregnancy (TP)

- Term pregnancy is defined as *“a birth after 37 weeks of gestation”*
- Preterm birth affects approximately 10% of live births in the United States and is the leading cause of neonatal death globally.

Normal Birthweight (NB)

- Normal birthweight is defined as *a birth of at least 5 pounds and 8 ounces”*
- Preterm birth with low birthweight is the second leading cause of infant mortality in the United States.

Methods



Data Collection

Table 1. Regular expressions to retrieve tweets about a term pregnancy (term) or normal birthweight (NB). The bold text indicates the string of the (slightly modified) sample tweet that matches the regular expression.

	Query Pattern	Outcome	Tweets
1	(?<!until\s)(?<!like\s)(?<!when\s)\bi(\W?m\sam) (((3[7-9]) (4[0-2]))\W?weeks) (full\W?term)) <ul style="list-style-type: none"> • <i>I'm 39 wks pregnant with a 2 year old and feel guilty for relaxing in the afternoon!</i> 	Term	4239
2	(?<!be\s)(?<!&\s)(?<!and\s)(?<!was\s)\b(((\d (1[0-9]) (2[0-1]))\W?days) ([1-3]\W?weeks)) (until (away from) from to) (my due date i(\W?m\sam) due\b) <ul style="list-style-type: none"> • <i>I have 9days til my due date</i> 	Term	3443
3	\b(my due date(\W?s\s sis) i(\W?m\sam) due) (in\s)?(((\d (1[0-9]) (2[0-1]))\W?days) ([1-3]\W?weeks))(!(\sfrom \ssooner \sbefore \safter)) <ul style="list-style-type: none"> • <i>I am due in 3 dayssssss</i> 	Term	1522
4	(?<!from\s)\b(((tomorrow today)(\W?s\s sis) (yesterday was)) my due date <ul style="list-style-type: none"> • <i>Can't believe 2days my due date! Getting induced Wednesday. Can't believe it's over</i> 	Term	1395
5	\b((my due date(\W?s\s sis) i(\W?m\sam) due) (tomorrow today) (my due date was yesterday) (i was due yesterday)) <ul style="list-style-type: none"> • <i>This is supposed to be my "last" dr. appt. since I'm due tmrw</i> 	Term	1167
6	\b(born birth delivered arrived came meet welcome is.*here introducing debut entrance)\b.* \b((5\W?pounds\.(s?(\W & and)s)?([8-9](1[0-5]))\W?ounces) ((6-9][10]\W?pounds\.(s?(\W & and)s)?([0-9](1[0-5]))\W?ounces)) <ul style="list-style-type: none"> • <i>Meet our beautiful son. 8 pounds and 10 ounces! We are so blessed</i> 	NB	4764
7	\b(born)\b.* \b((((2\.[5-9]) ([3-4]\.[0-9]))\W?kilograms) ((2,?[5-9][0-9][0-9]) ([3-4],[0-9][0-9][0-9]))\W?grams)\b <ul style="list-style-type: none"> • <i>Excited & proud to introduce our daughter. Born on 20/01/16 at 2:43pm. 3.8kg, 52cm long</i> 	NB	41

Negative Examples

Tweet	Type	Date	Tweet +/-	User +/-
Today's my due date, but life clearly had other plans #5weeksold today!	Term	04/01/2016	-	-
My sister-in-law had her baby! Born January 22 at 8:44pm - 8lbs. 4oz. We really appreciate our first year anniversary gift!	NB	01/23/2010	-	-

Manual Annotation

- Annotated 2683 tweets by 853 users ($K = 0.80$)
 - 750 out of 853 users posted positive TP and NB tweets
 - When adding the 50 day threshold, we were left with 684 users who posted positive TP and NB tweets for same pregnancy

Tweet vs. User Level

Tweet	Type	Date	Tweet +/-	User +/-
I'm 2 weeks away from my due date. I've gotta keep my blood pressure normal 😊	Term	09/17/2016	+	+
Meet my darling. Born at 17:15, weighing 2.8kg. Mom is in loads of pain	NB	10/12/2016	+	+
mine still fits over my 39+ week belly with some room to spare. (today is my due date).	Term	05/31/2016	+	-
My baby was born on Saturday 8/2 @ 2:45pm. 7lbs. 3oz. 20 in.	NB	08/05/2014	+	-

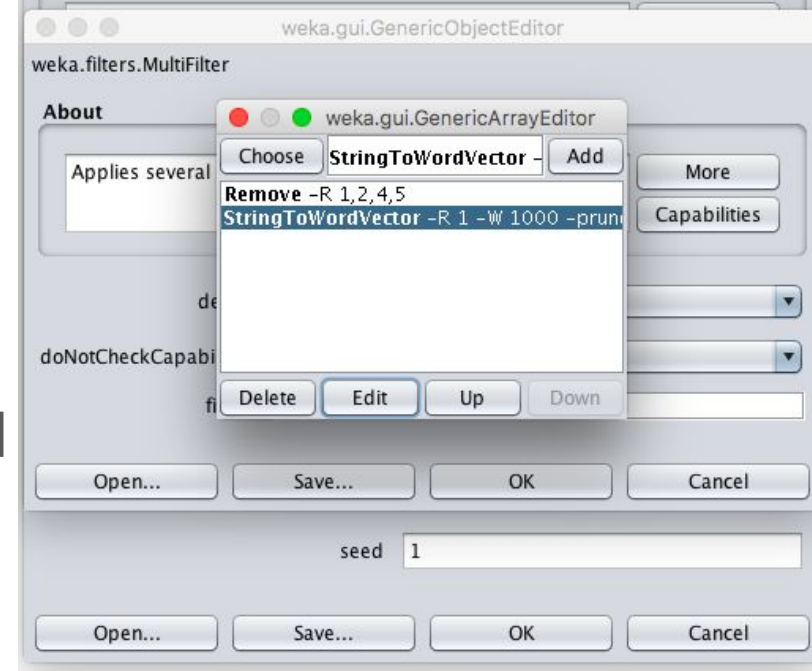
Classification

- Used annotated data to train and evaluate machine learning algorithms
- 80/20 split into training and test sets
 - 80%: 682 users, 2103 tweets
 - 20%: 171 users, 580 tweets
- Sets are stratified based on user type (same pregnancy, different pregnancy, one negative)



Tweet-Level Classification

- Text pre-processing (created word vectors)
- Classifiers:
 - ZeroR (Baseline)
 - J48 Decision Tree
 - Logistic Regression
 - Support Vector Machine



```
pic 0.0221
pictur 0.1276
play 1.2196
pm _normalbirthweight_ _url_ 0.2066
pm _normalbirthweight_ and 1.1763
pm _normalbirthweight_ in 0.6346
pm _normalbirthweight_ inch 3.0069
pm and 3.9401
pm he 0.0819
pm on 0.3457
pm she 0.7639
pm weigh 0.4089
pm weigh _normalbirthweight_ 0.7011
pound 0.0493
pregnant for 0.2432
pretti 7.4213
push 0.0654
```

User-Level Classification

- These classifiers were used to identify a cohort of pregnant women who:
 - Posted a positive NB tweet
 - Posted a positive TP tweet
- Posted TP and NB tweet about same pregnancy (50 day threshold)

Results: Tweet-Level

Classifier	Precision	Recall	F1 Score
ZeroR	0.880	1.000	0.936
J48 Tree	0.903	0.980	0.940
Logistic Regression	0.931	0.935	0.933
Support Vector Machine	0.896	0.996	0.943
Ensemble	0.910	0.993	0.950

Results: User-Level

Classifier	Precision	Recall	F1 Score
ZeroR	0.941	0.927	0.934
J48 Tree	0.947	0.905	0.925
Logistic Regression	0.958	0.832	0.891
Support Vector Machine	0.940	0.920	0.930
Ensemble	0.947	0.920	0.933

Discussion

- This pipeline will identify large comparator groups for other observational studies (birth defects, miscarriage, stillbirth, and preterm birth)
- The performance of the pipeline may improve with:
 - Additional pre-filtering rules
 - Added restrictions to the regular expressions
 - More annotated training data.
- Applicability to other fields/projects beyond birth defects

Lessons Learned

- Significance is everything
- Research is all around you
- Language is complex



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