Building community healthcare supply chain resilience

FIReS Webinar 2

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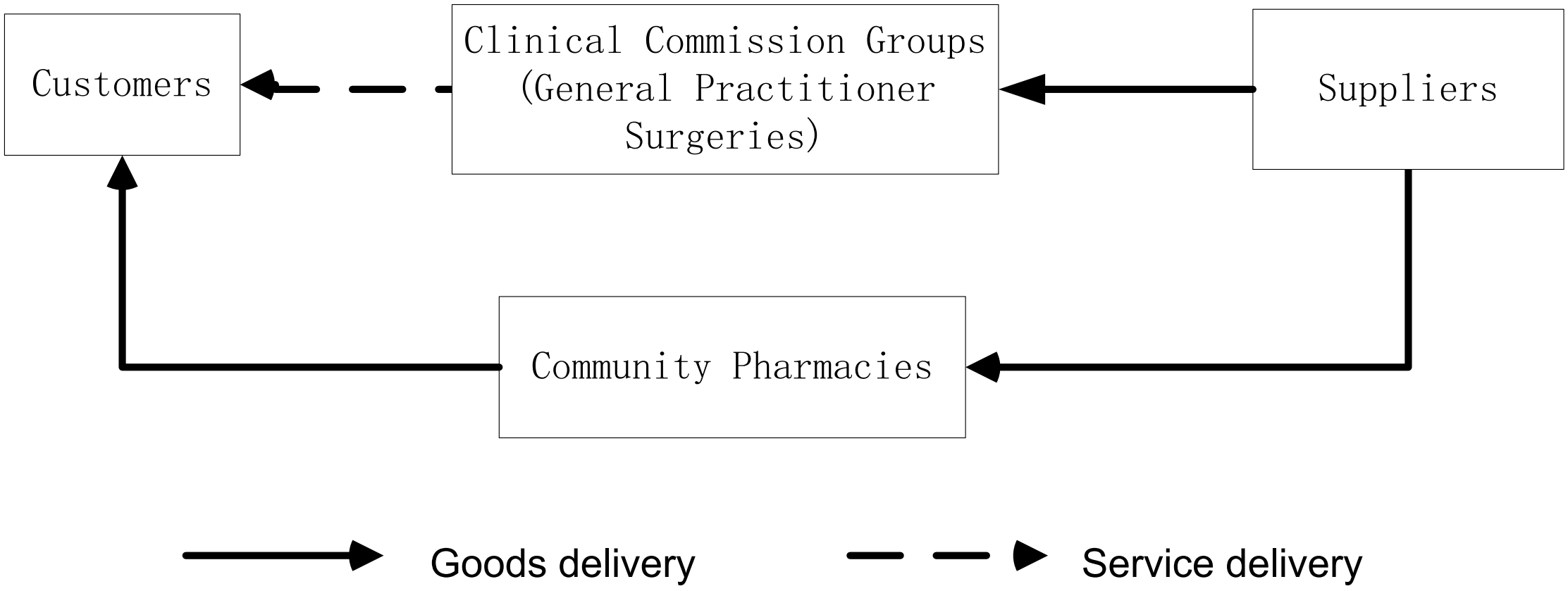
Agenda

1. Community healthcare (primary care) supply chain resilience

2. Natural Language Processing (NLP) of twitter data

A healthcare supply chain



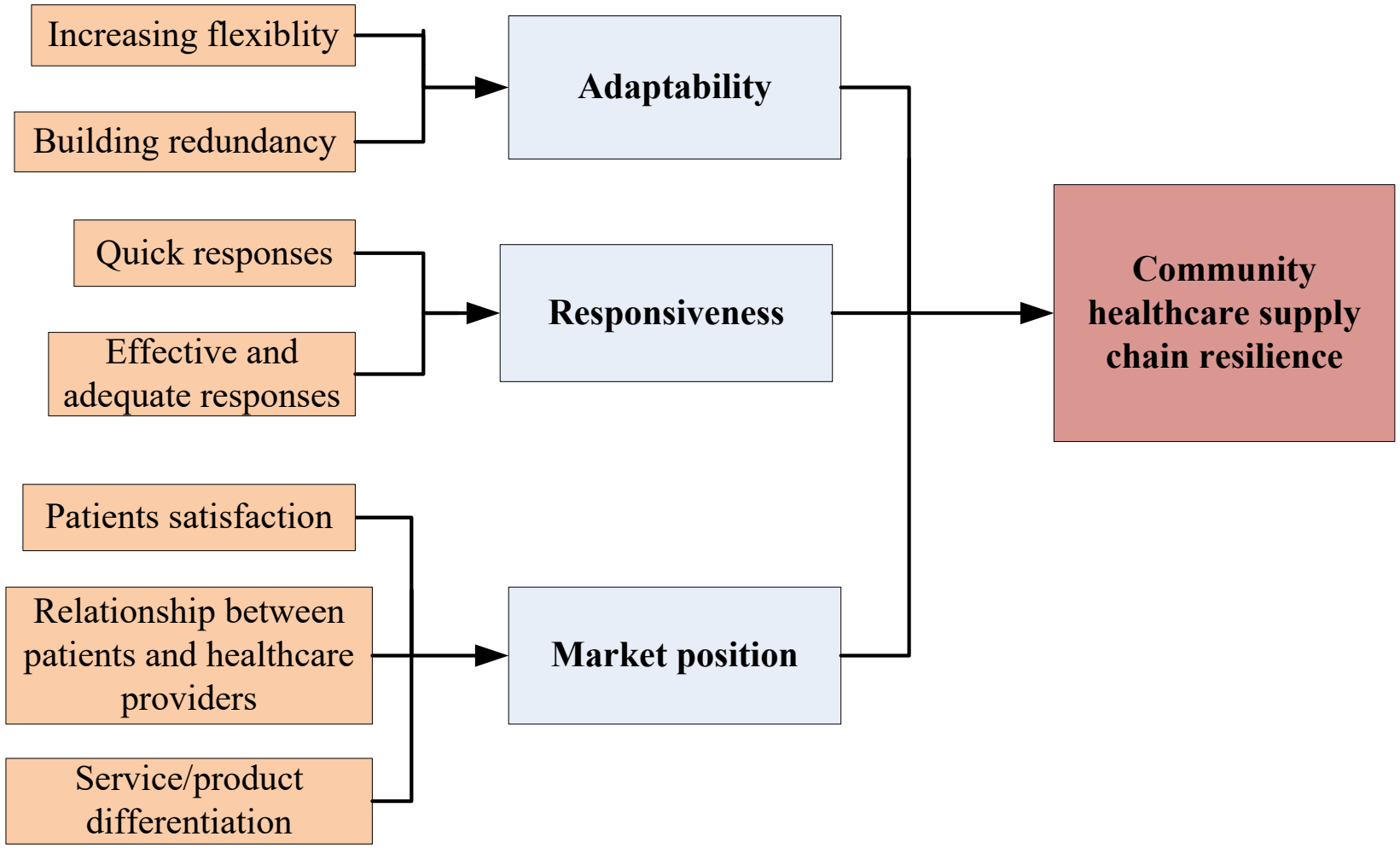
Research conducted

1. Focus group meetings with healthcare technology providers and Essex County Council, including Ocado technology, CGI, and Iotic

2. An electronic survey with the public from May to Jun 2020

3. Big data analysis of 420,000 tweets (text mining and natural language processing), from Clinical Commission Groups (CCGs), pharmacies, pharmaceutical suppliers/distributors

Community healthcare resilience



Key areas of community healthcare

1. Access to medical information before and during lockdown

2. Access to medical consultation/treatment before and during lockdown

3. Order and collection of prescription medicines before and lockdown

Findings from focus group meetings

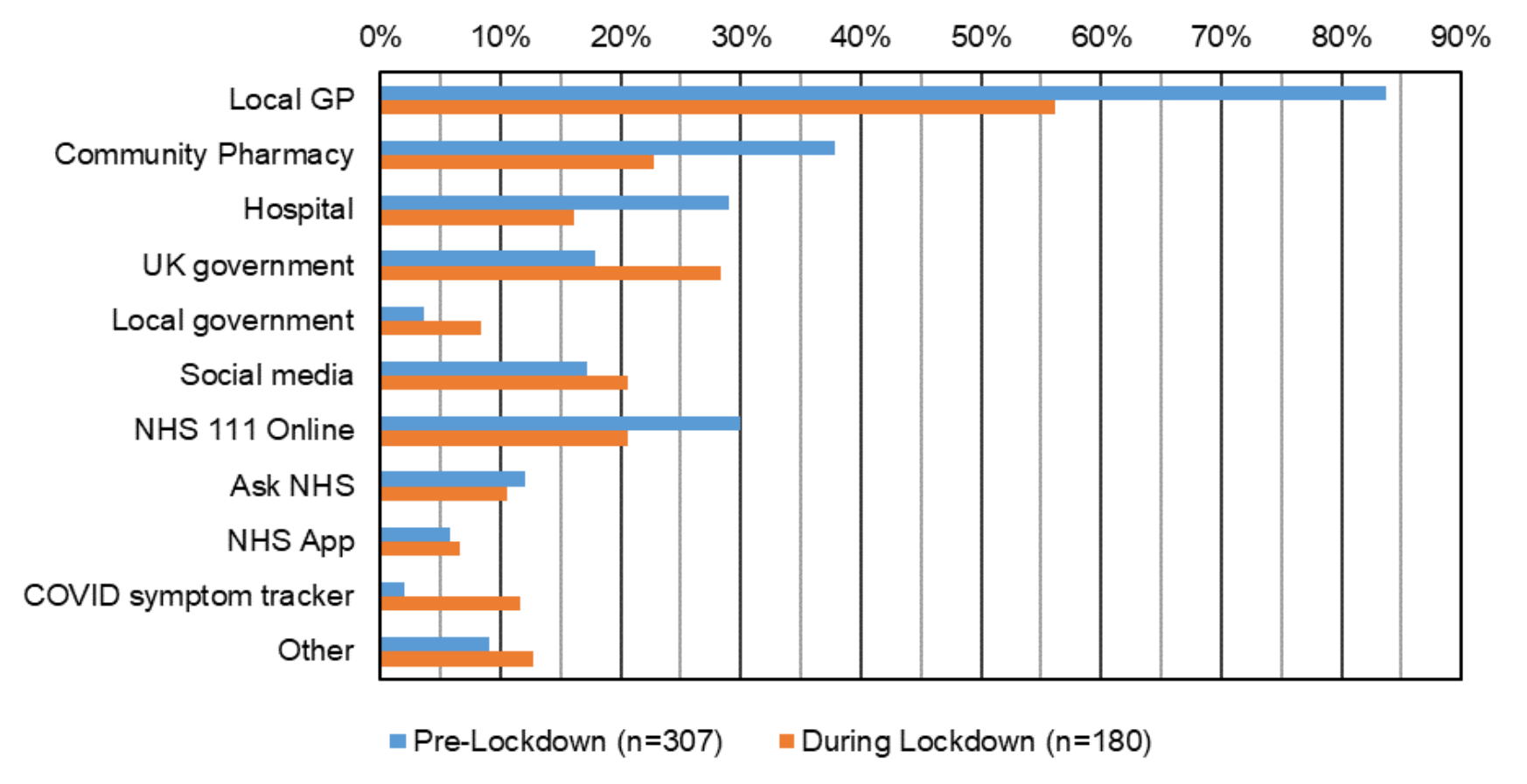
1. Future digital healthcare services will be intelligent developments of existing digital services

2. Making a transformative shift in community healthcare provision is led by patients' needs and structured around the citizen and community level;

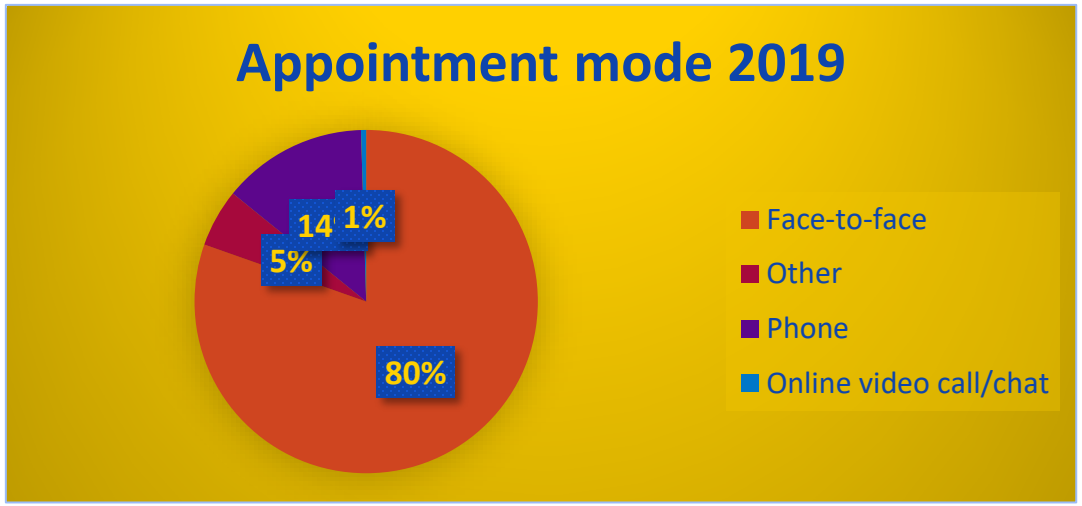
3. Digital technologies create an efficient interface and enhance communication with patients;

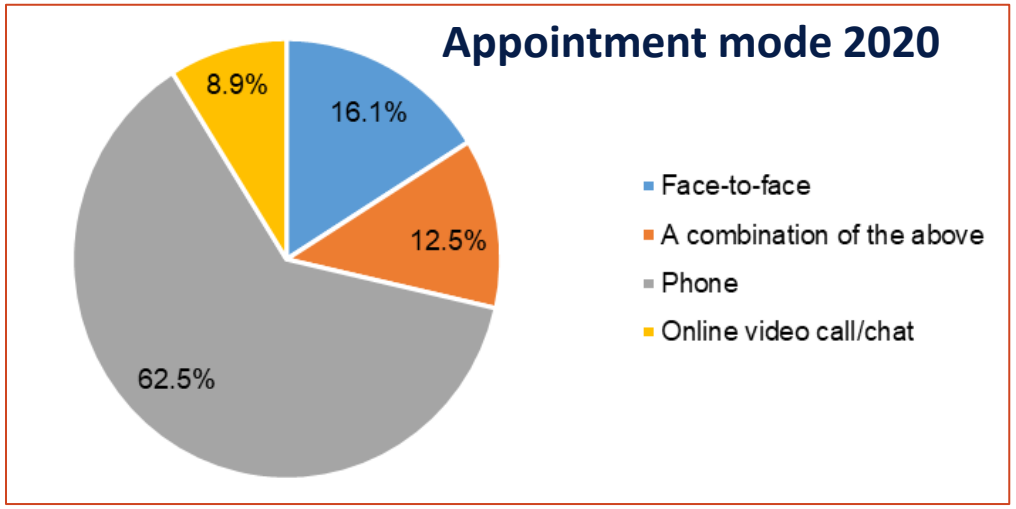
4. Delivering a smart healthcare supply chain requires innovative interoperability of technologies, services and patients in an ecosystem, to inform and direct primary, secondary and home healthcare provision.

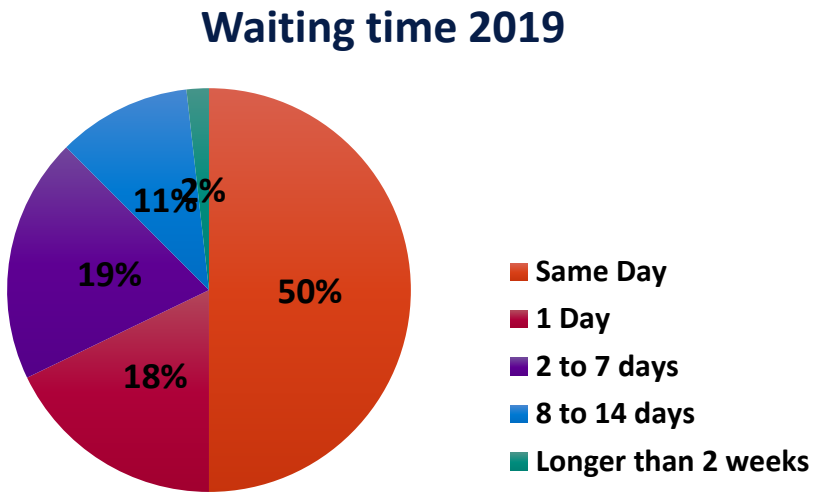
Sourced used to access medical information

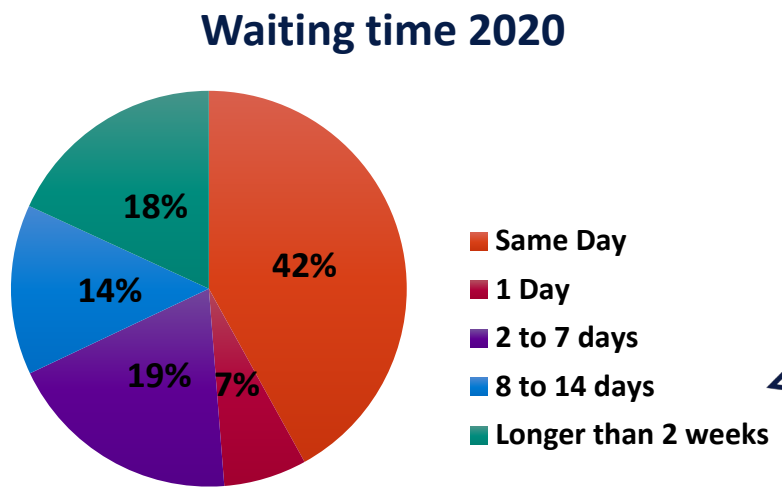


Medical consultation appointments









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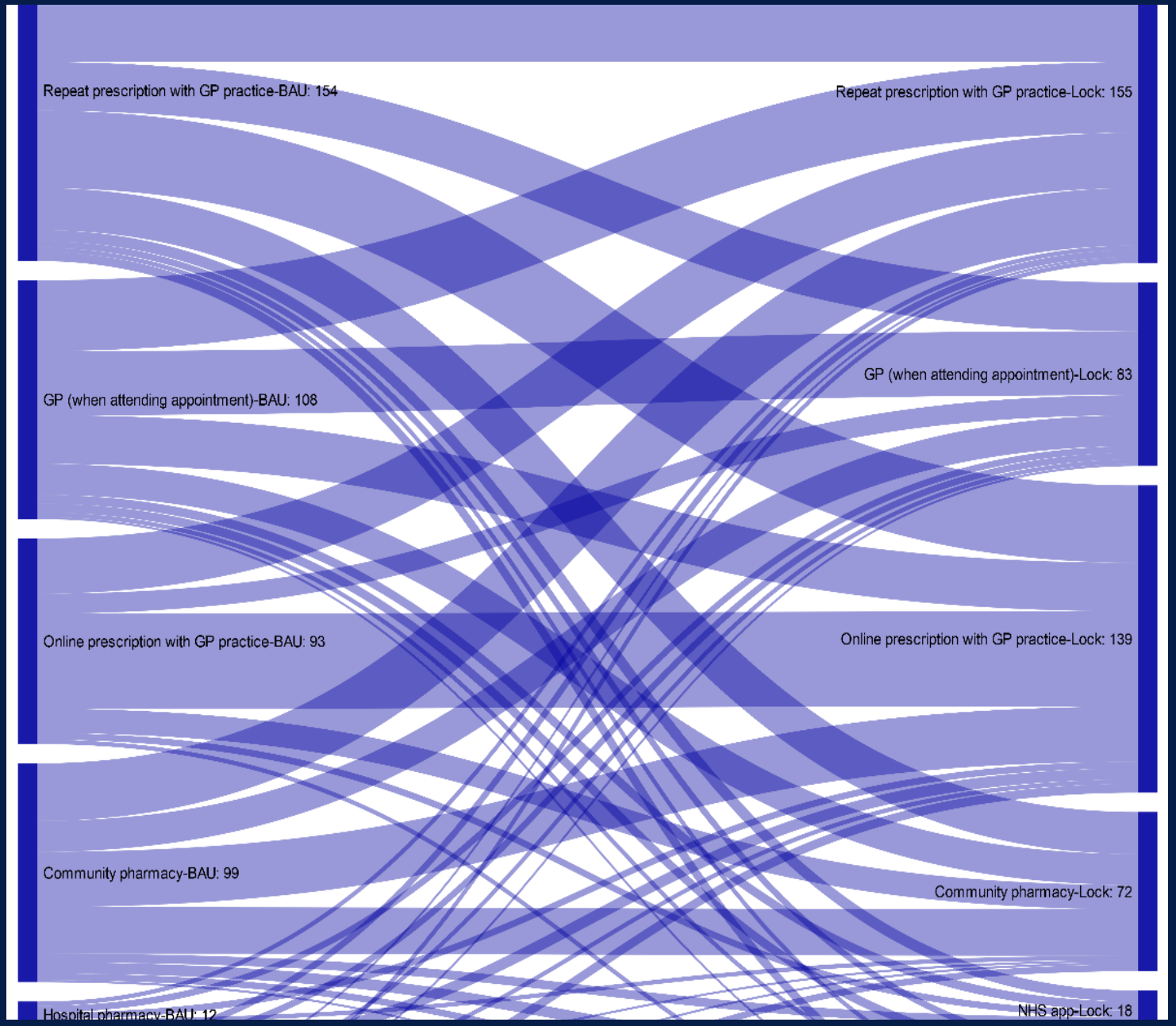
Ordering medicine before and after lockdown



The use and awareness of technologies by the public

1. During lockdown, among 307 responses, 39% were aware of the healthcare apps, and 61% were unaware of them.

2. During lockdown, among 117 responses, 24% used apps, and 76% did not use.

Community healthcare resilience

Resilience Dimensions	Sub-dimensions		Access to medical information	Access to medical consultation/treatment	Order and collection of prescription medicines
Adaptability	Increasing flexibility	Flexible production or supply volume	Y	Y	Y
		Flexible product/service portfolio	Y	Y	Y
		Flexible distribution	Y	Y	Y
		Introducing new products/services	Y	Y	Y
	Building redundancy	Excess capacity in production or transportation		N	Yes in distribution, but not in dispensing medicines or serving patients in pharmacies
		Multiple suppliers	Y	N	Yes in distribution, but not in dispensing medicines or serving patients in pharmacies
		Limited capacity utilisation	Not available	Y	Y
Responsiveness	Quick response		Y	Y	Y
	Effective and adequate response		N	Y	Y
Market position	Patients' satisfaction		N	Y	Y
	Relationship between patients and healthcare providers		Not available	Y	Y
	Service/product differentiation		Y	Y	Y

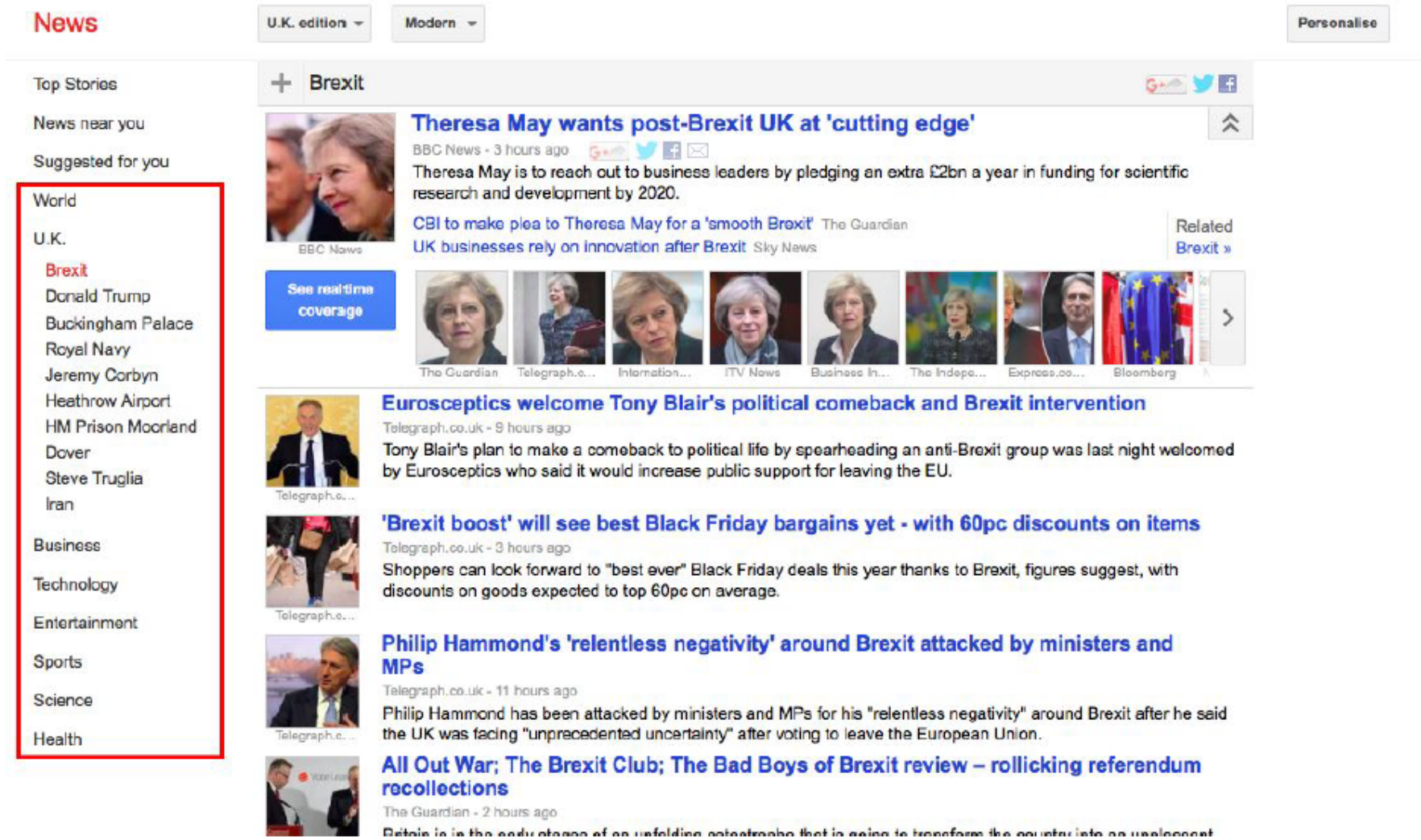
Natural Language Processing

- **Natural Language Processing** (**NLP**) is a branch of **Artificial Intelligence** (AI) that studies how **machines** understand human **language**. Its goal is to build systems that can make sense of text and perform tasks like translation, grammar checking, or topic classification

Sentiment analysis

- How it works:
- ML multi-classification task: positive, neutral, negative
- Words and emoji as predictive features: e.g., ☺ “in positive”, love “in positive”, and ☹ “in negative”, frustrated “in negative”

Topic classification



Topic classification

- How it works:
- ML multi-classification task: politics vs technology vs sports
- Word distribution is predictive: each topic is formed by a combination of relevant words

Tweets posted by stakeholders in a healthcare supply chain

Twitter account	No. of tweets	Twitter account	No. of tweets
Suppliers		**Pharmacies**	
Basildon Chemicals	111	Lalys Pharmacy	104
Harrisons Direct	180	Lloyds Pharmacy	1549
HDA UK	107	Boots Pharm Assoc	92
Mawdsleys UK	18	Dull Pharmacy	214
Medicines for Europe	237	Well Pharmacy	103
PHONIX group	26	PSNC	258
McKesson UK	17	Chemist+Druggist	725
AAH pharmaceuticals	250	Your UK Pharmacy	147
…		National Pharmacy Association	816
CCGs		Royal Pharmaceutical Society	796
NHS Southwark CCG	134	…	
NHS Lambeth CCG	193	Total Number of Tweets	344,021
NHS Greenwich CCG	124	**Customers (using hashtags below)**	
NHS Mid Essex CCG	810	#lockdown, #covid, #coronavirus, #NHS	3,587,276
West Essex CCG	857		
North Central London CCG-Haringey	164		
Southampton CCG	443		
Bradford CCG	993		
West London CCG	695		
North Central London CCG-Islington	249		
Total number of tweets			**3,931,297**

Twitter data from customers

- “A large-scale COVID-19 Twitter chatter dataset for open scientific research” published by Georgia State University’s Panacea Lab
- We used version 69.0 from Panacea Lab
- 1st March to 15th Aug 2020, tweets containing COVID related keywords and hashtags, including COVID, COVID19 (-19), coronavirus, pandemic, etc.
- Cleaned version with no retweets: 43,907,518 twitter IDs
- 15% of the Twitter IDs are hydrated using “Twarc” to extract original tweets and metadata from the IDs, such as time, date, user, user profile, etc.

Sentiment analysis of the tweets

- Rule-based methods perform the analysis based on a set of predefined rules, and the representative Python libraries are TextBlob and VADER

- Feature-based methods identify features from data and rely on machine learning techniques to train the analysis from these features. Logistic Regression, Naïve Bayes, Support Vector Machine Neural Network or ensembles

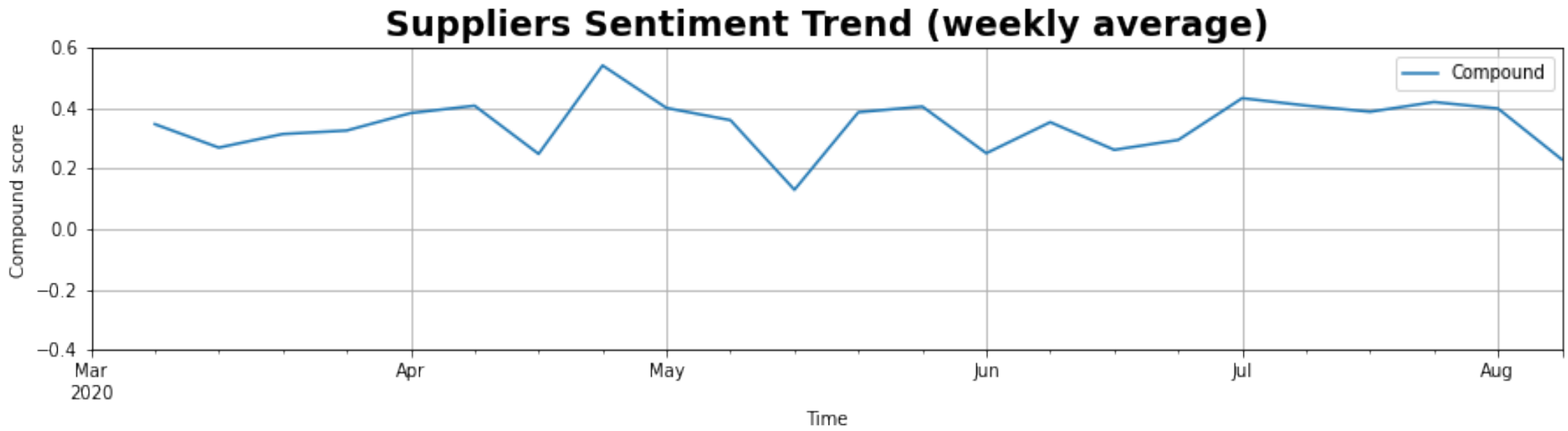
- Embedding-based methods leverage both machine learning and rule-based methods to detect semantics

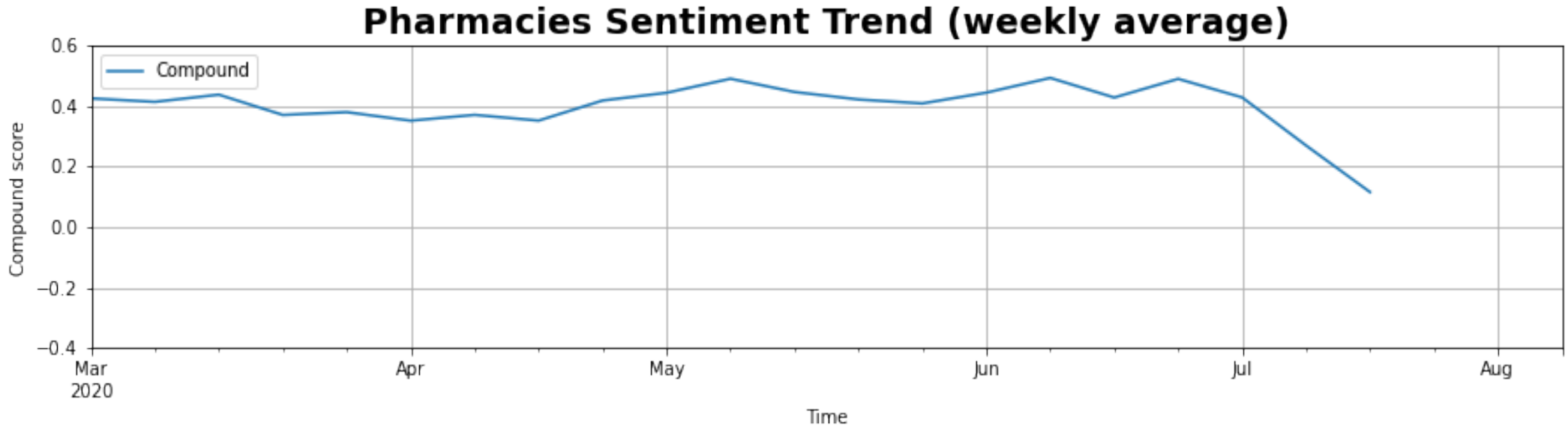
Creating training set for sentiment analysis

- 100K training set by automatic labelling (noisy labelling method)
- 5K training set by manual human annotations (Amazon Mechanical Turk)
- Training data set from Sandford Sentiment 140 (1.6m tweets), or Stanford Sentiment Treebank (11,855 sentences)

Pipeline of NLP

Tweets pre-processing	Feature extraction	Machine learning classification/prediction
Removing symbols and numbers	Vectorize tweets	Logistic Regression
Tokenization (N-grams)	Bag of words	Decision trees
Stop words	TF-IDF	Naïve bayes
Lemmatization	Neural embeddings	Neural network


Suppliers Sentiment Trend (weekly average)
Compound
Compound score
0.6
0.4
0.2
0.0
−0.2
−0.4
Mar
2020
Apr
May
Jun
Jul
Aug
Time


Pharmacies Sentiment Trend (weekly average)
Compound
Compound score
0.6
0.4
0.2
0.0
−0.2
−0.4
Mar
2020
Apr
May
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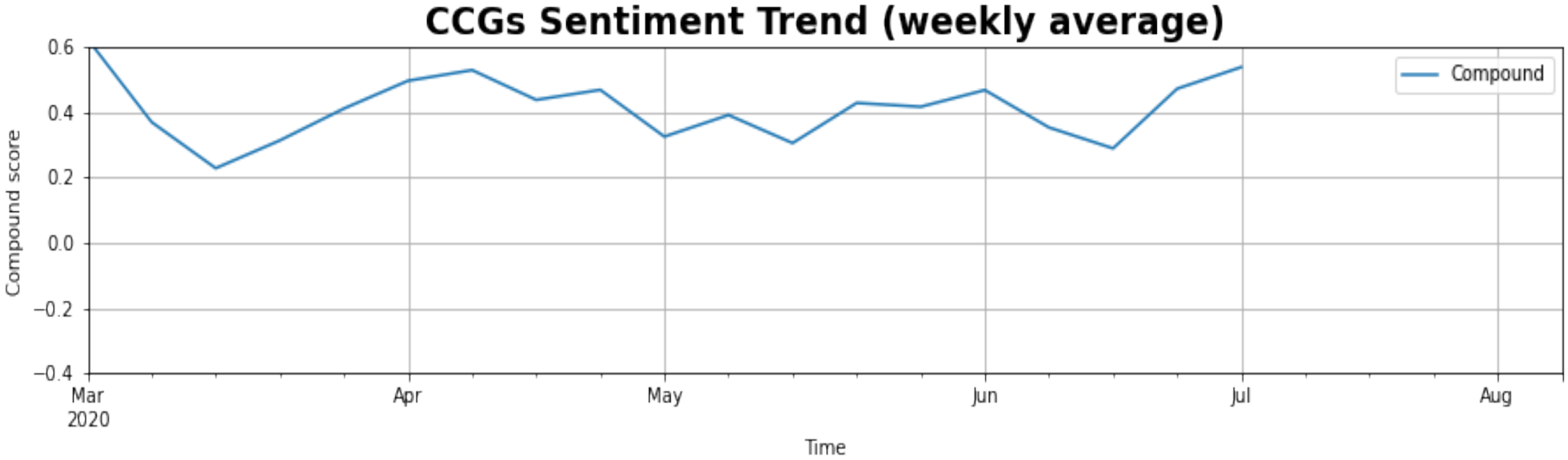
Time


CCGs Sentiment Trend (weekly average)
Compound
Compound score
0.6
0.4
0.2
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−0.2
−0.4
Mar
2020
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May
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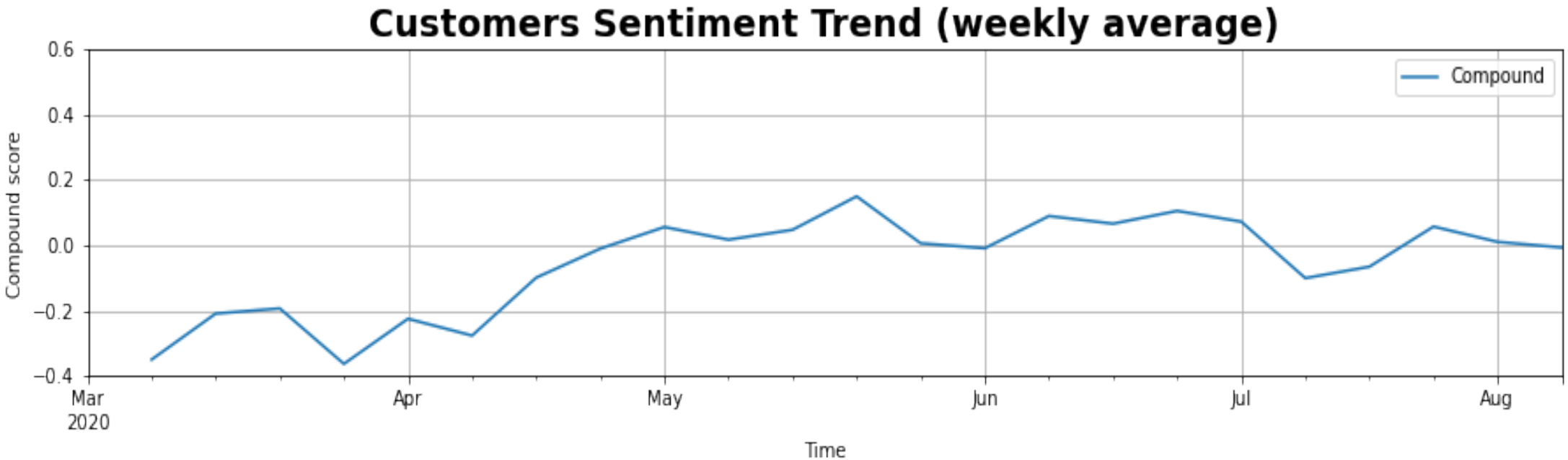
Time


Customers Sentiment Trend (weekly average)
Compound
Compound score
0.6
0.4
0.2
0.0
−0.2
−0.4
Mar
2020
Apr
May
Jun
Jul
Aug
Time

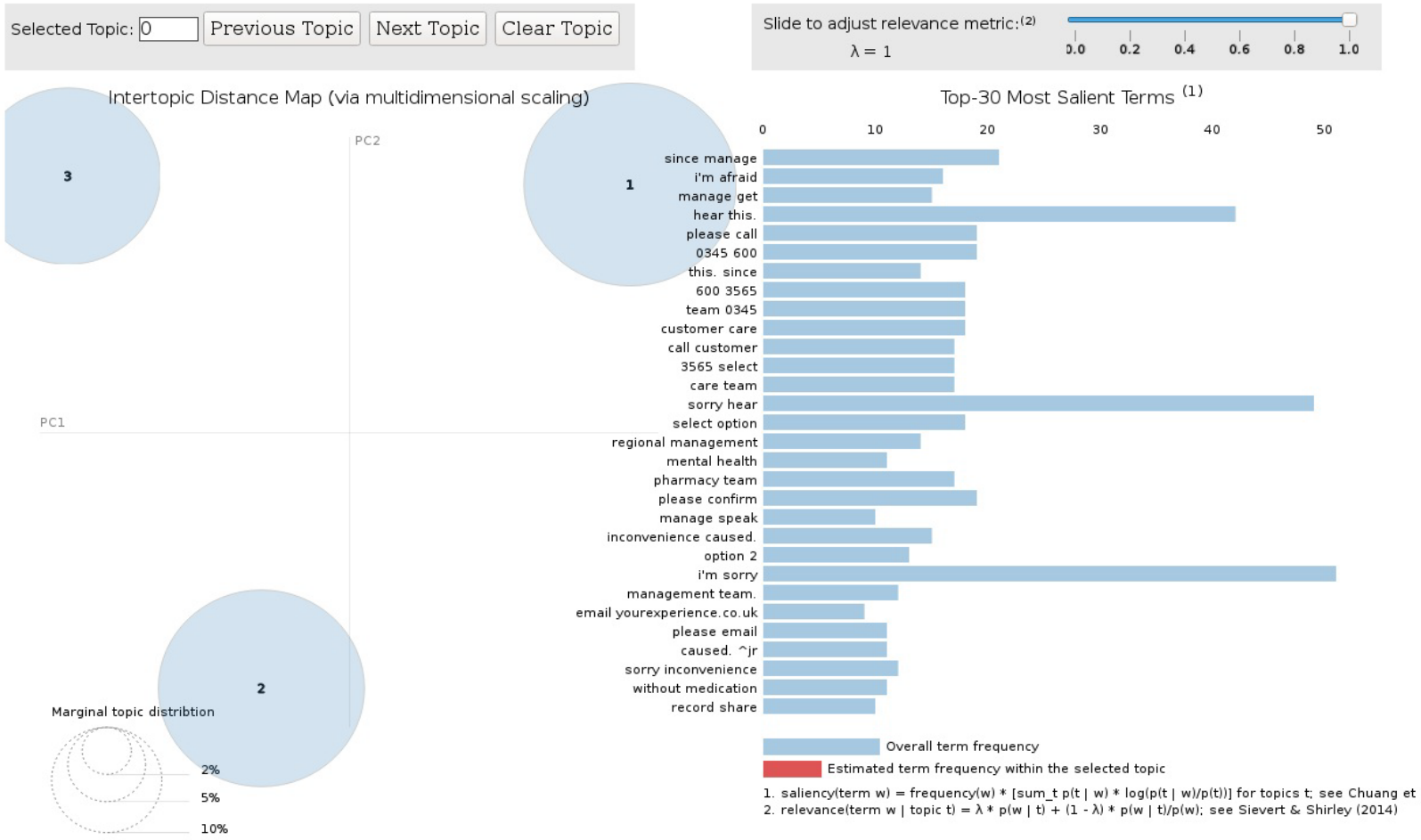
LDA modelling

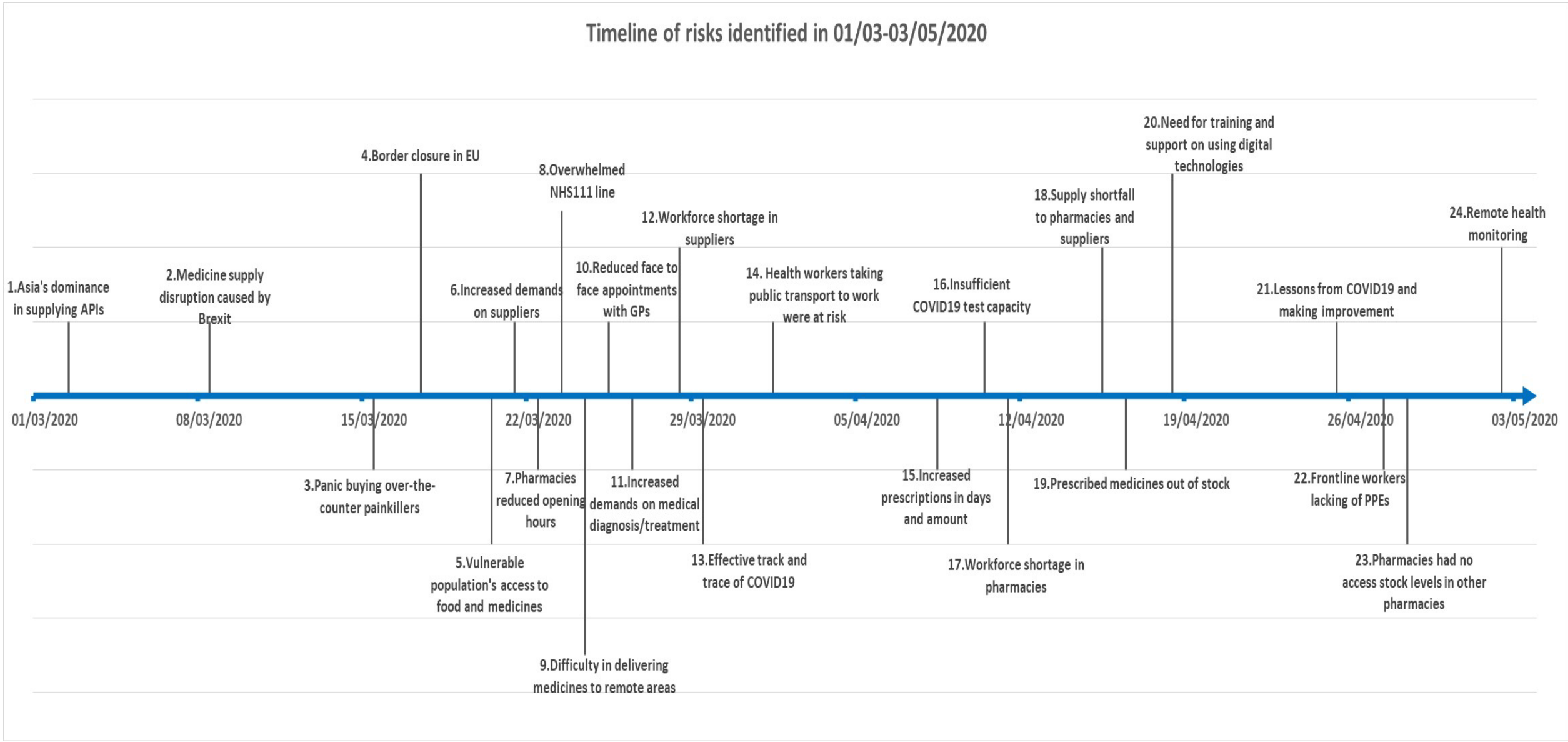
- Latent Dirichlet Allocation (LDA) is a generative probabilistic model developed for collections of discrete data called text corpora (Blei et al. 2003).

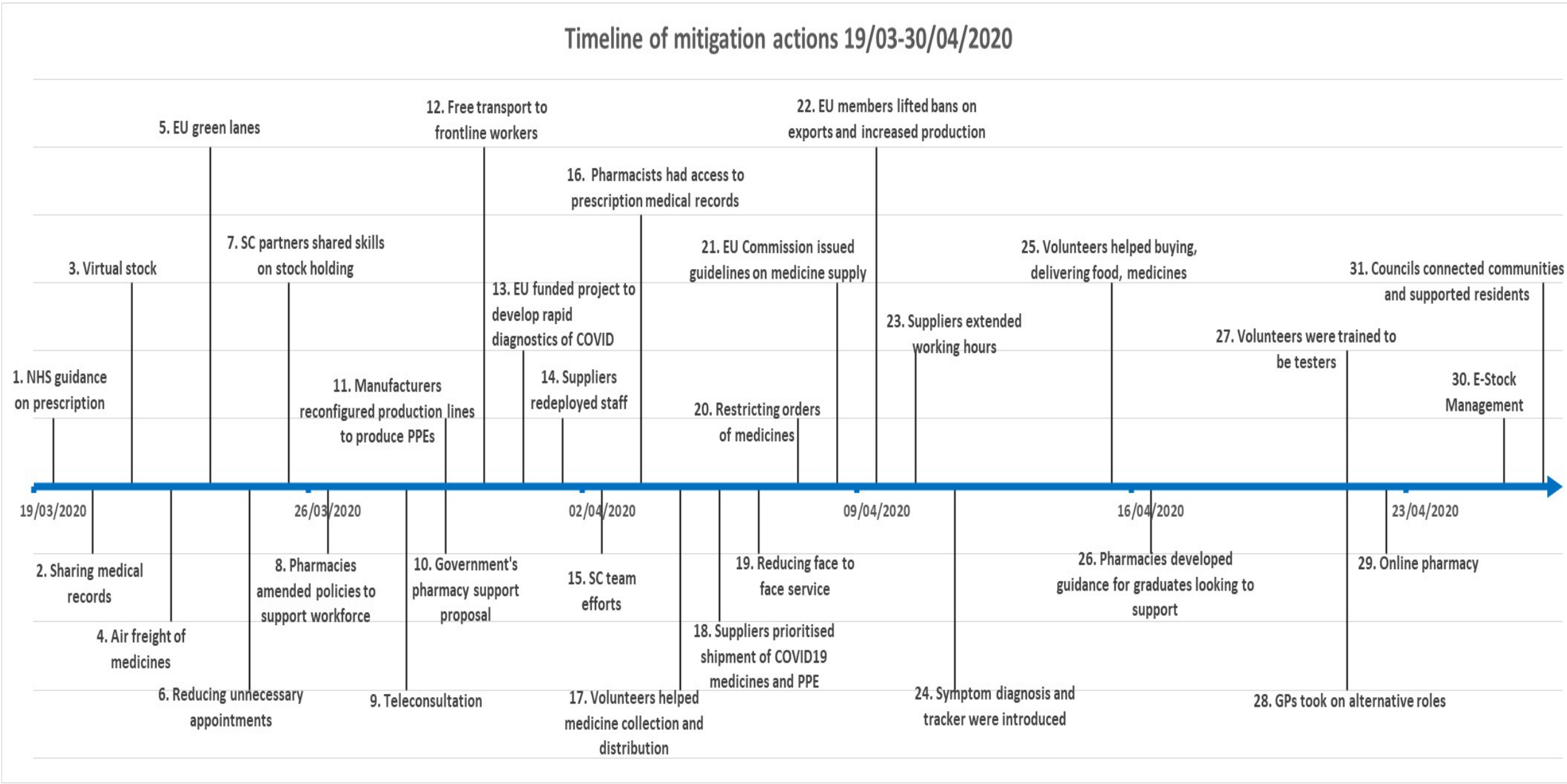
- We are interested in learning the various distributions, the set of *N* topics $\boldsymbol{Z}$, their association with word probabilities $\boldsymbol{\varphi}$, the topic of each word $\boldsymbol{W}$, and the particular topic mixture of each document $\boldsymbol{\theta}$. Given the parameters α and β, the joint probability of a document can be written as:

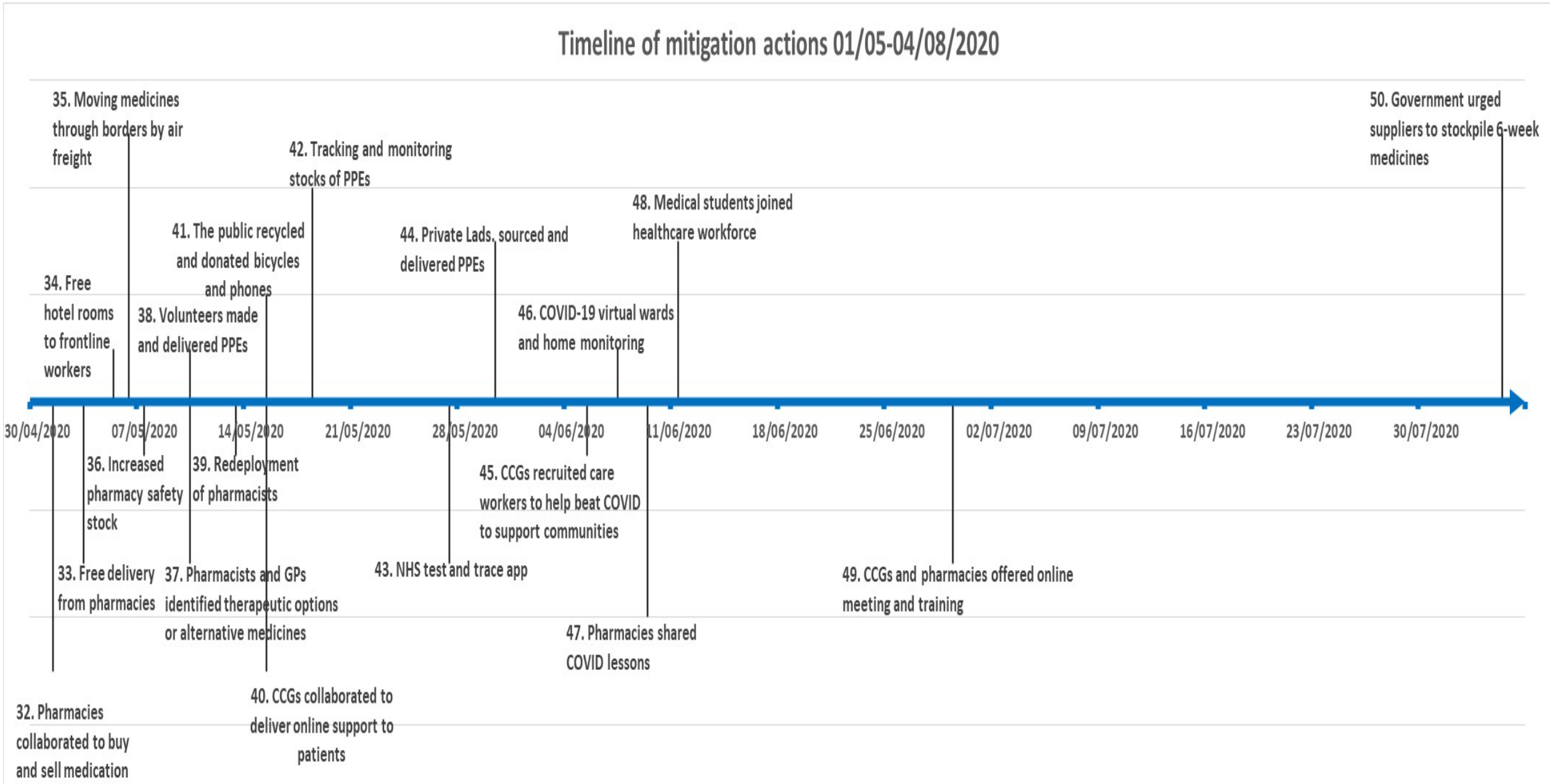
$$P(\boldsymbol{W}, \boldsymbol{Z}, \boldsymbol{\theta}, \boldsymbol{\varphi}\,; \alpha, \beta) = \prod_{i=1}^{K} P(\varphi_i; \beta) \prod_{j=1}^{M} P(\theta_j; \alpha) \prod_{t=1}^{N} P(Z_{j,t} \,|\theta_j) P(W_{j,t} |\varphi_i)$$

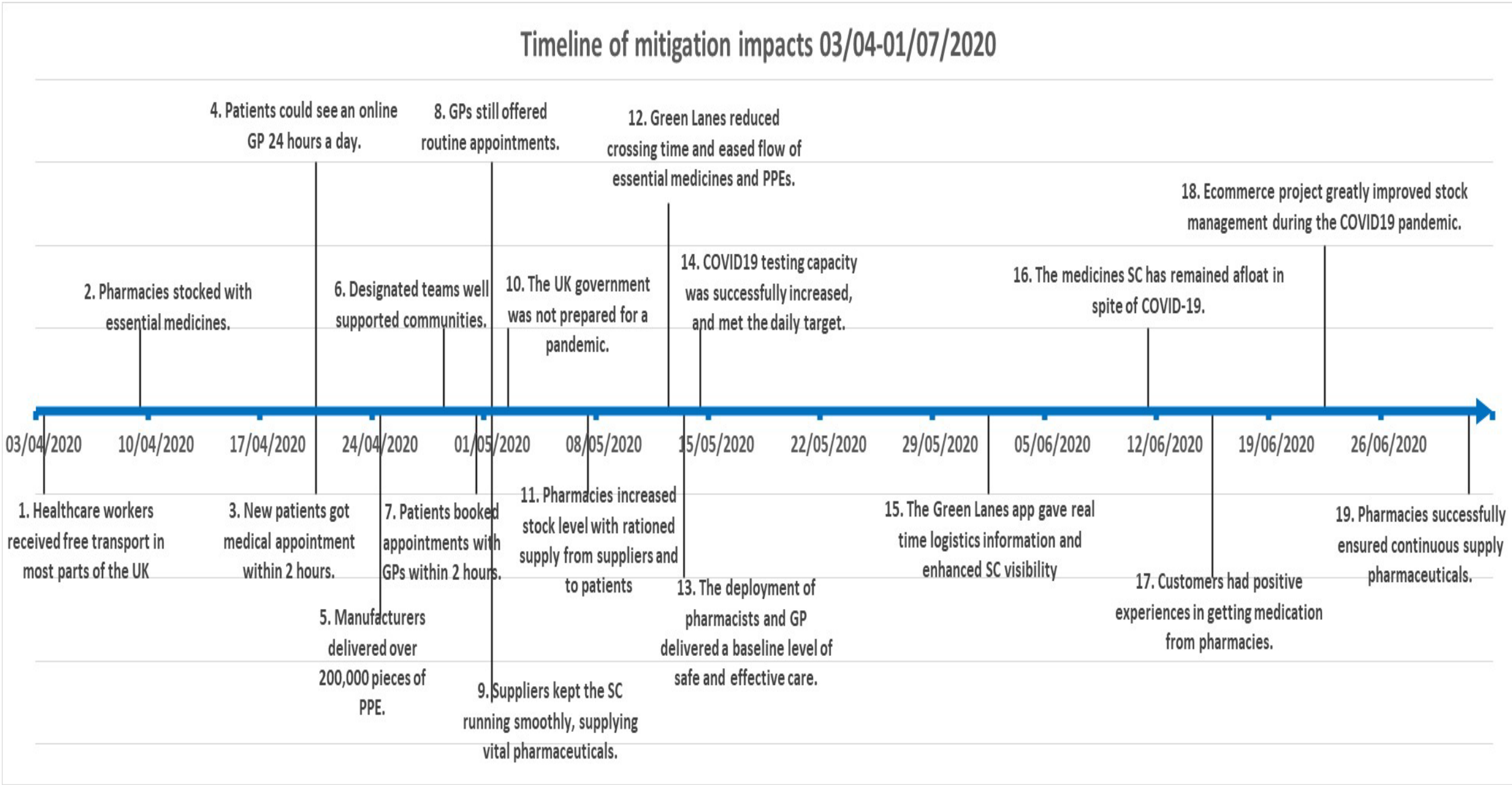
Topics identified for Pharmacies Negative tweets




Timeline of risks identified in 01/03-03/05/2020
1.Asia's dominance in supplying APIs
2.Medicine supply disruption caused by Brexit
3.Panic buying over-the-counter painkillers
4.Border closure in EU
5.Vulnerable population's access to food and medicines
6.Increased demands on suppliers
7.Pharmacies reduced opening hours
8.Overwhelmed NHS111 line
9.Difficulty in delivering medicines to remote areas
10.Reduced face to face appointments with GPs
11.Increased demands on medical diagnosis/treatment
12.Workforce shortage in suppliers
13.Effective track and trace of COVID19
14. Health workers taking public transport to work were at risk
15.Increased prescriptions in days and amount
16.Insufficient COVID19 test capacity
17.Workforce shortage in pharmacies
18.Supply shortfall to pharmacies and suppliers
19.Prescribed medicines out of stock
20.Need for training and support on using digital technologies
21.Lessons from COVID19 and making improvement
22.Frontline workers lacking of PPEs
23.Pharmacies had no access stock levels in other pharmacies
24.Remote health monitoring
01/03/2020
08/03/2020
15/03/2020
22/03/2020
29/03/2020
05/04/2020
12/04/2020
19/04/2020
26/04/2020
03/05/2020


Timeline of mitigation actions 19/03-30/04/2020
1. NHS guidance on prescription
2. Sharing medical records
3. Virtual stock
4. Air freight of medicines
5. EU green lanes
6. Reducing unnecessary appointments
7. SC partners shared skills on stock holding
8. Pharmacies amended policies to support workforce
9. Teleconsultation
10. Government's pharmacy support proposal
11. Manufacturers reconfigured production lines to produce PPEs
12. Free transport to frontline workers
13. EU funded project to develop rapid diagnostics of COVID
14. Suppliers redeployed staff
15. SC team efforts
16. Pharmacists had access to prescription medical records
17. Volunteers helped medicine collection and distribution
18. Suppliers prioritised shipment of COVID19 medicines and PPE
19. Reducing face to face service
20. Restricting orders of medicines
21. EU Commission issued guidelines on medicine supply
22. EU members lifted bans on exports and increased production
23. Suppliers extended working hours
24. Symptom diagnosis and tracker were introduced
25. Volunteers helped buying, delivering food, medicines
26. Pharmacies developed guidance for graduates looking to support
27. Volunteers were trained to be testers
28. GPs took on alternative roles
29. Online pharmacy
30. E-Stock Management
31. Councils connected communities and supported residents
19/03/2020
26/03/2020
02/04/2020
09/04/2020
16/04/2020
23/04/2020


Timeline of mitigation actions 01/05-04/08/2020
35. Moving medicines through borders by air freight
42. Tracking and monitoring stocks of PPEs
50. Government urged suppliers to stockpile 6-week medicines
48. Medical students joined healthcare workforce
41. The public recycled and donated bicycles and phones
44. Private Lads, sourced and delivered PPEs
34. Free hotel rooms to frontline workers
38. Volunteers made and delivered PPEs
46. COVID-19 virtual wards and home monitoring
30/04/2020
07/05/2020
14/05/2020
21/05/2020
28/05/2020
04/06/2020
11/06/2020
18/06/2020
25/06/2020
02/07/2020
09/07/2020
16/07/2020
23/07/2020
30/07/2020
36. Increased pharmacy safety stock
39. Redeployment of pharmacists
45. CCGs recruited care workers to help beat COVID to support communities
33. Free delivery from pharmacies
37. Pharmacists and GPs identified therapeutic options or alternative medicines
43. NHS test and trace app
49. CCGs and pharmacies offered online meeting and training
47. Pharmacies shared COVID lessons
32. Pharmacies collaborated to buy and sell medication
40. CCGs collaborated to deliver online support to patients


Timeline of mitigation impacts 03/04-01/07/2020
1. Healthcare workers received free transport in most parts of the UK
2. Pharmacies stocked with essential medicines.
3. New patients got medical appointment within 2 hours.
4. Patients could see an online GP 24 hours a day.
5. Manufacturers delivered over 200,000 pieces of PPE.
6. Designated teams well supported communities.
7. Patients booked appointments with GPs within 2 hours.
8. GPs still offered routine appointments.
9. Suppliers kept the SC running smoothly, supplying vital pharmaceuticals.
10. The UK government was not prepared for a pandemic.
11. Pharmacies increased stock level with rationed supply from suppliers and to patients
12. Green Lanes reduced crossing time and eased flow of essential medicines and PPEs.
13. The deployment of pharmacists and GP delivered a baseline level of safe and effective care.
14. COVID19 testing capacity was successfully increased, and met the daily target.
15. The Green Lanes app gave real time logistics information and enhanced SC visibility
16. The medicines SC has remained afloat in spite of COVID-19.
17. Customers had positive experiences in getting medication from pharmacies.
18. Ecommerce project greatly improved stock management during the COVID19 pandemic.
19. Pharmacies successfully ensured continuous supply pharmaceuticals.
03/04/2020
10/04/2020
17/04/2020
24/04/2020
01/05/2020
08/05/2020
15/05/2020
22/05/2020
29/05/2020
05/06/2020
12/06/2020
19/06/2020
26/06/2020

Twitter data

- An alternative source to collect risk data
- Real time twitter data analysis enables stakeholders to identify risks at early stage and make quick responses
- Risks and risk mitigations can be included in a central depositary

Thank you and
Any question?

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