

# India nudges to contain COVID-19 pandemic: a reactive public policy analysis using machine-learning based topic modelling

--Manuscript Draft--

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| <b>Abstract:</b>  | India locked down 1.3 billion people on March 25, 2020, in the wake of COVID-19 pandemic. The economic cost of it was estimated at USD 98 billion, while the social costs are still unknown. This study investigated how government formed reactive policies to fight coronavirus across its policy sectors. Primary data was collected from the Press Information Bureau (PIB) in the form press releases of government plans, policies, programme initiatives and achievements. A text corpus of 260,852 words was created from 396 documents from the PIB. An unsupervised machine-based topic modelling using Latent Dirichlet Allocation (LDA) algorithm was performed on the text corpus. It was done to extract high probability topics in the policy sectors. The interpretation of the extracted topics was made through a nudge theoretic lens to derive the critical policy heuristics of the government. Results showed that most interventions were targeted to generate endogenous nudge by using external triggers. Notably, the nudges from the Prime Minister of India was critical in creating herd effect on lockdown and social distancing norms across the nation. A similar effect was also observed around the public health (e.g., masks in public spaces; Yoga and Ayurveda for immunity), transport (e.g., old trains converted to isolation wards), micro, small and medium enterprises (e.g., rapid production of PPE and masks), science and technology sector (e.g., diagnostic kits, robots and nano-technology), home affairs (e.g., surveillance and lockdown), urban (e.g. drones, GIS-tools) and education (e.g., online learning). A conclusion was drawn on leveraging these heuristics are crucial for lockdown easement planning. |
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All media release files are available from the PIB database (<https://pib.gov.in/AllRelease.aspx?MenuId=3>)

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# 1 India nudges to contain COVID-19 pandemic: a reactive public policy analysis 2 using machine-learning based topic modelling

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8 Kingdom

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11

12 **Abstract**

13 India locked down 1.3 billion people on March 25, 2020, in the wake of COVID-19 pandemic.  
14 The economic cost of it was estimated at USD 98 billion, while the social costs are still unknown. This  
15 study investigated how government formed reactive policies to fight coronavirus across its policy  
16 sectors. Primary data was collected from the Press Information Bureau (PIB) in the form press releases  
17 of government plans, policies, programme initiatives and achievements. A text corpus of 260,852  
18 words was created from 396 documents from the PIB. An unsupervised machine-based topic  
19 modelling using Latent Dirichlet Allocation (LDA) algorithm was performed on the text corpus. It was  
20 done to extract high probability topics in the policy sectors. The interpretation of the extracted topics  
21 was made through a nudge theoretic lens to derive the critical policy heuristics of the government.  
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23 external triggers. Notably, the nudges from the Prime Minister of India was critical in creating herd  
24 effect on lockdown and social distancing norms across the nation. A similar effect was also observed  
25 around the public health (e.g., masks in public spaces; Yoga and Ayurveda for immunity), transport  
26 (e.g., old trains converted to isolation wards), micro, small and medium enterprises (e.g., rapid  
27 production of PPE and masks), science and technology sector (e.g., diagnostic kits, robots and nano-  
28 technology), home affairs (e.g., surveillance and lockdown), urban (e.g. drones, GIS-tools) and  
29 education (e.g., online learning). A conclusion was drawn on leveraging these heuristics are crucial for  
30 lockdown easement planning.

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32 **Keywords:** Nudges; Computational Social Science; Text Mining; Policy; COVID-19

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36 Cambridge, Cambridge – CB2 1PX, United Kingdom37 Funding: Bill and Melinda Gates Foundation through Gates Cambridge Scholarship under the grant  
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# Summary of Comments on PONE-D-20-13777\_reviewer.pdf

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Page: 7

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Number: 1

This study appears to have already been published by these authors in the journal *Computers and Society* (see link below). Am I not understanding something?

<https://arxiv.org/abs/2005.06619>



## 39 1. Introduction

40

41 India locked down 1.3 billion people on March 25, 2020, in the wake of novel coronavirus  
42 COVID-19 pandemic<sup>1</sup> The Prime Minister of the country, Mr Narendra Modi, in his address to the  
43 nation, appealed to the nation that ‘... 21 days is critical to breaking the infection cycle... or else the  
44 country and your family could be set back 21 years...’ (1). In a sense, the government used the nudge  
45 of ‘nationalism’ as an effective measure to control the disease spread. This nudge had critical public  
46 policy implications because it successfully convinced 1.3 billion<sup>2</sup> population to abide by lockdown rules  
47 at high economic and social costs. The estimated economic cost of the Phase 1 lockdown of 21 days (   
48 March 25 to April 14, 2020) was estimated to be almost USD 98 billion (2).<sup>3</sup> While nudging is a design-  
49 based approach that has been used in several domains for priming human behaviour, it is often used  
50 as the ‘best-guesses’, to tailor government policies(3). It is challenging to ascertain the reliability and  
51 replicability of similar nudge in producing desired behaviour change. Nevertheless, it is imperative to  
52 untangle the nudges produced by the government policies for coping future national challenges like  
53 COVID-19. In this case, understanding how the central Government of India (GoI) informed policies  
54 to handle the ongoing national crisis is crucial for lockdown mitigation planning. It has implications in  
55 planning resilience and future-proofing extensive national emergencies.

56 <sup>4</sup> Big data and machine learning have proven to be a reliable technique in mining and distilling  
57 patterns in data and transform into predictive analytics. This technique has the promise to filter  
58 intricate information into meaningful behaviour metrics and hence could be applied to <sup>5</sup> harvest  
59 intricate nudges from policy datasets that will warrant replicability of desired behaviours. This study  
60 intends to explore the response of the GoI since the outbreak of COVID-19 in the country by collecting  
61 open public data published by the Government's nodal agency - Press Information Bureau of India  
62 (PIB) (4). <sup>6</sup> The social data-science methodology of topic modelling based on text processing was  
63 employed (5) to examine the key areas of interventions that were deliberated by various ministries of  
64 GoI during the emergency phase. The topics of interventions which eventually nudged the citizen

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Number: 1

Consider adding the date that these remarks were made to add more context.
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Number: 2

Revise "population" to "people".
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Number: 3

Consider revising these sentences for clarity.
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Number: 4

Consider revising this sentence for structure as "big data" is not the technique.
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Number: 5


Respectfully "...harvest intricate nudges..." does not make a lot of sense.
- 

Number: 6


15 behaviours were extracted from a textual policy database since the emergence of the first case in the  
66 country, on January 30, 2020. The probabilistic distribution curves generated through Latent Dirichlet  
67 Allocation (LDA) algorithm was used for texts mining (6) on a text- database, prepared from the press  
68 releases, published between January 15, 2020, and April 14, 2020. These topics were then processed  
69 to elaborate government nudging for influencing citizen's behaviour in the wake of coronavirus  
70 pandemic.

71 Topic modelling is a widely used computational social science method that has its basis in text  
72 mining and natural language processing. 2 is an unsupervised machine learning technique that  
73 automatically analyses text data to determine cluster words for a set of documents (7). Topic  
74 Modelling (TM) as garnered significant importance in political science and rhetoric analysis (8).  
75 Researchers have used TM to investigate reactions of different political communities on the same  
76 news for understanding political polarisation in the United States (9). Similarly, in Korea, Kim & Jeong  
77 (10) have used TM on twitter dataset to analyse the temporal variation of the socio-political landscape  
78 of the 2012 Korean Presidential Election. In Germany, researchers have used a TM-approach to  
79 explore the multi-dimensionality of political texts and the discourses of public policies since National  
80 Elections of 1990 (11). This study aided in understanding the polarising shifts in policy interventions  
81 that modulated the political narratives in Germany. More recent applications of TM includes crisis  
82 identification in urban areas for evidence-based policymaking (12), deep narrative analysis for deriving  
83 intervention points for distributive energy justice in poverty (13) and informed public policy design in  
84 public administration (14).


85 None of the above application of TM has explored the policy reactions of a government  
86 towards handling a national emergency. 4 Although TM entails sophisticated extraction of topics by  
87 algorithmically evaluating their 'relevance', integrating this as a guide for future nudging can produce  
88 the desired 'priming' and 'selective optimisation'. In general, the intention is to use nudge tactics as a  
89 solution to the last-mile problem, i.e. the gap between people's long-term intentions and their

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Number: 1

This section describes methods and would be better placed in that section.
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Number: 2

Would note that topic modeling need not be unsupervised necessarily. There are supervised and semi-supervised applications.
- 
- 

Number: 3

Define as abbreviation at the first use.
- 
- 

Number: 4

The point of this sentence is unclear.
-

everyday actions, for meeting future challenges. The integration of TM for nudge identification from government policy and press releases defines the novelty of this study. This study will aid policymakers and government agencies in India to plan lockdown easement from a multi-dimensional public policy perspective. The policy inferences presented in this study is also critical for other countries that are affected by the COVID-19 crisis and under extended lockdown.

## 2. Materials and methods

### 2.1 Data collection and pre-processing

Data for this study were collected from the media releases of policies and plans of different ministries in the Press Information Bureau (PIB) platform (4). English news and information with the keyword ‘coronavirus’, ‘COVID’, ‘COVID-19’ and ‘nCoV’ was collected and aggregated in a text format from January 15, 2020, and April 14, 2020. Manual filtering of the press and media releases based on the above keywords resulted in 396 documents from around 42 ministries of the Government of India. The entire text corpus from these documents consisted of 260,852 words. We classified these documents into 14 public policy categories, as illustrated in Table 1. Besides, we have also included COVID-19 briefings from the Prime Minister’s Office in the policy categories (see Table 1).

Table 1. Policy categories extracted from the ministries of the Government of India

| Sl. No. | Policy sectors       | News and information from ministries   |
|---------|----------------------|--|
| 1       | Agriculture and Food | Agriculture and Farmers Welfare; Fisheries, Animal Husbandry & Dairying; Food Processing Industries  |
| 2       | AYUSH                | Ayurvedic, Yoga and Naturopathy, Unani, Siddha and Homeopathy  |
| 3       | Chemicals            | Chemicals and Fertilizers; Commerce & Industry; Steel  |
| 4       | Electronics & IT     | Information & Broadcasting; Communications; Electronics & IT   |
| 5       | Health               | Health and Family Welfare  |
| 6       | Home Affairs         | Home Affairs; Defence; Finance   |
| 7       | Labour & Commerce    | Micro, Small & Medium Enterprises; Skill Development and Entrepreneurship; Textiles; Corporate Affairs; Personal, Public Grievances & Pensions |
| 8       | MHRD                 | Human Resource Development   |
| 9       | PMO                  | Prime Minister’s Office  |
| 10      | Power                | Power; Coal; Petroleum & Natural Gas; New & Renewable Energy   |
| 11      | Science & Technology | Science and Technology; Statistics & Programme Implementation;   |
| 12      | Social Justice       | Rural Development; Social Justice & Empowerment; Tribal Affairs; Development of North-East Region; Minority Affairs; Panchayat Raj; Culture    |
| 13      | Transport            | Civil Aviation; Railways; Shipping; Tourism; Road, Transport and Highways  |
| 14      | Urban                | Housing and Urban Affairs; Environment, Forest and Climate Change Environment, Forest and Climate Change                                       |



Number: 1

These statements in the introduction section are premature and would be more appropriate for the discussion section.

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Number: 2

Would it not have been useful to include the terms "corona virus" and "coronavirus"?

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Number: 3

The foundation of this analysis seems to be somewhat predicated on the mutual exclusivity of these policy categories. Is it a reasonable assumption that these categories have no overlap?

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## 2.2 Topic Modelling using Latent Dirichlet Allocation (LDA)

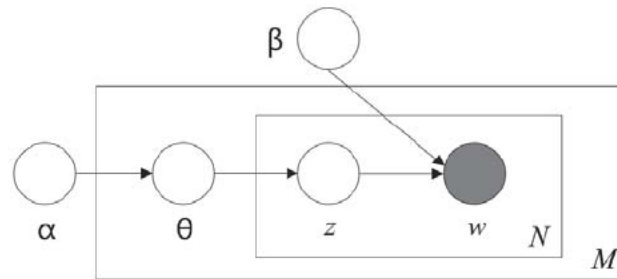


Fig 1. Graphical model representation of LDA. (Source: (6))

Topic modelling refers to the task of identifying **1** topics that best describes a set of documents. It is an unsupervised machine learning technique that automatically analyses text data to determine cluster words from a set of documents. It is based on the basic idea that each document can be expressed as a distribution of topics, and each topic can be described by a distribution of words (6). The basic terminology used in LDA is based on the language of ‘text collection’, referring to entities such as “words”, “documents” and “corpora”. These terms are defined as (after (6)),


- A *word* is the basic unit of discrete data, defined to be an item from a vocabulary indexed by  $\{1, \dots, V\}$ . We represent words using unit-basis vectors that have a single component equal to one and all other components equal to zero. Thus, using superscripts to denote components, the  $v$ th word in the vocabulary is represented by a  $V$ -vector  $w$  such that  $w^v = 1$  and  $w^u = 0$  for  $u \neq v$ .
- A *document* is a sequence of  $N$  words denoted by  $\mathbf{w} = (w_1, w_2, \dots, w_N)$ , where  $w_N$  is the  $n$ th word in the sequence.
- A *corpus* is a collection of  $M$  documents denoted by  $D = \{\mathbf{w}_1, \mathbf{w}_2, \dots, \mathbf{w}_N\}$ .

Latent Dirichlet allocation (LDA) is a Bayesian mixture model for discrete data in which topics are **2** uncorrelated. The objective of topic modelling is to extract latent semantic topics from large volumes of textual documents (i.e., corpora). LDA is a widely used topic modelling (TM) technique, with recent applications spanning across political science and rhetoric analysis (8–10,15,16), disaster management

 Number: 1

Are topics here being equated to the policy categories from Table 1?

---

 Number: 2

I have a hard time believing that the topics are uncorrelated in actuality. This would seem to violate the conditions for using LDA. Can the authors explain either why this was not the case or how the application of LDA required assumptions.

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(12,17,18) and public policy (13,14,19). Fig 1 illustrates the probabilistic graphical model of LDA, and the probability calculation formula is illustrated in eq. 1.

$$p(D|\alpha, \beta) = \prod_{d=1}^M \int p(\theta_d|\alpha) \left( \prod_{n=1}^{N_d} \sum_{z_{dn}} p(z_{dn}|\theta_d) p(w_{dn}|z_{dn}, \beta) \right) d\theta_d \quad (1)$$

where, the boxes in Fig 1 are “plates” representing replicates. The outer plate represents documents ( $M$ ), while the inner plate represents the repeated choice of topics ( $z$ ) and words ( $w$ ) within a document ( $N$ ). ‘ $\theta$ ’ is the topic distribution for document, i.e. ‘ $\alpha$ ’, ‘ $\beta$ ’ are two hyperparameters of the Dirichlet distribution (see eq. 1). The third hyperparameter is the ‘number of topics’ that the algorithm will detect since LDA cannot decide on the number of topics by itself. We use our judgement and the *ldatuning* package (20) in R to determine the number of topics in each of the topic models (discussed later in detail).


The analysis consisted of three main steps. The first step was the pre-processing of the documents by removing all the stop words (e.g., articles, such as “a,” “an,” and “the,” and prepositions, such as “of,” “by,” and “from”), numbers, and punctuation characters and converted the text to lowercase in the corpora. And some general words appear in most of the government media releases like “name of ministers”, “secretary”, “union government” and courtesy words like “Shri”, “honourable”, “respected”, “sir” and “thank you”. We constructed a list of additional stop words that were colloquial terms in Indian-English and removed them from the text-corpus. This step is usually called lemmatisation (21). Lemmatisation also involved removal of inflectional ending of words, and converting the grammatical form of a word into the base or dictionary form (known as Lemma) (21).

The second step was to fit the model using the lemmatised corpora. Using the *tidytext* package in the R programming language, we converted the article into a document-term-matrix (DTM) as per the specification of *tidydata* rules [see chapter 1, (22)]. Each sentence was treated as a document in the DTM, that resulted in ( $M$ ) unique documents that had  $w$  (words) and  $z$  (topics) as per LDA probability model specification (see eq. 1 and Fig 1). We adopted an iterative approach where we first specified the number of topics based on our judgement of the government’s policy nudges and then tuned the

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 Number: 1  
Please describe the extent and role of the authors' judgment here.

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Here and throughout please be sure to cite the version of R and the version of the function.

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Unless this is referring to a point in the present document this should be cited with the source document and location of the relevant text.

appropriate number of topics as per the benchmarking metrics of Arun et al. (23), Cao et al. (24), Griffiths and Steyvers (5) and Deveaud et al., (25). These metrics were part of the *ldatuning* package in R (20); similar approach was also adopted by (14,19). We used the R package *topicmodels* to fit the LDA model (26).

The third step included visualisation and manual validation of the topics. For visualisation, we have used the *ggplot2* package in R (27). We have also estimated and visualised co-occurrence of high-frequency keywords in the corpora using the methodology of Jan van Eck and Waltman (28). The extracted topic was further analysed and interpreted concerning reactive policy steps using the epistemology of nudge theory in behavioural public policy (29).

### **2.3 Evaluating topic models on nudge theory**

Nudge theory is mainly concerned with the design of choices, which influences the decisions we make. It seeks to improve understanding and management of the 'heuristic' influences on human behaviour which is central to 'changing' people (30). Epistemologically, Thaler and Sunstein (30) used nudge policies and interventions as an application of a conceptual framework called libertarian paternalism. The authors contend that retaining the freedom to choose is the best safeguard against a misguided policy intervention. The 'nudging' approach is paternalistic in the sense of motivating behaviour change that aligns with the target population's deliberative preferences (29). Thus, libertarian paternalism relies on the assumption that each human being makes many decisions automatically and almost unthinkingly each day by following some innate rules of thumb (29). It had been reported in literature that from a policy-instrumentation perspective, nudges constitute a less coercive form of government intervention compared to more traditional policy tools such as regulations and taxations (31). While policy interventions can provide the right directions, it cannot suggest the promptness of the behaviour change. The behavioural nudge tactics, here, enable solving this last mile problem of policy intervention implementation success through the use of "soft" techniques.

179 A comprehensive literature review on the application of nudge theory in public policy and  
180 public management by Van Deun et al., (31) found that about 40% of the articles linked to health  
181 policies and almost 20% related to environmental policies. Other nudge sector included land and rural  
182 policies, financial policies, transport policies, law, social security, education and digitalization policies  
183 (31). More importantly, this theory has been in practice in the British Government (now independent)  
184 through the Behavioural Insight Unit (also known as the 'Nudge' Unit) (32).

185 The nudge theoretic approach has been used by the British Government to tackle the early  
186 stages of coronavirus pandemic in the UK (33). The behavioural nudges that were deliberated to the  
187 public included 'wash your hands, do not touch your face, do not shake hands with others, stay at  
188 home if you feel ill, and self-isolate if you have a continuous cough' (33). Through this study, we  
189 wanted to understand how the Government of India used nudges as a public policy measure to fight  
190 the coronavirus outbreak.

### 191 3. Results

#### 192 Topic co-occurrences

193 A keyword co-occurrence network was constructed with the 260,852 words **3**brpora that  
194 shows a connected network of high-frequency words (see Fig 1). Words or terms that were mentioned  
195 **4** least 50 times in the text corpus were considered as high-frequency words. The co-occurrence  
196 representation has two components. Fig 1a illustrates a weighted network diagram of the high-  
197 frequency words. The weights were estimated based on the co-occurrences of a single word; the size  
198 of the bubble describes the relative weight associated with the words. Words like 'infection', 'virus',  
199 'technology', 'testing', 'surveillance', 'passenger' and 'quarantine' had the highest weight and most  
200 interconnections, indicating the possible policy focus points during the early stage of the outbreak in  
201 India (between late-January to early-March). The general policy during this phase was on the  
202 containment of the cases. Extensive thermal screening of the passengers was conducted at the

- 1

Number: 1

This does not seem to have direct bearing on the methods and I am not sure why it is here.
- 1

Number: 2

None of this highlighted text belongs in the methods section.
- 1

Number: 3

Is "corpora" misplaced here?
- 1

Number: 4

On what basis is less than or equal to 50 instances of a word considered "high frequency"? Is this just an arbitrary threshold. If so then perhaps a threshold based on the number of total words or based on the number of words per topic would be more appropriate.

203 airports. During this stage, public policy was geared towards surveillance at the international borders.  
204 It remained a significant strategy until the national lockdown from March 24, 2020, until May 2020.

205 Similarly, Fig 1b illustrates the heat-map of the high-frequency words during the analysis  
206 period. The darker shades of grey in the heat-map indicate the policy points (or words) that had high  
207 frequency in the media briefs of the Government of India through the **Press Information Bureau (PIB)**.  
208 The darker shades of grey also illustrate higher co-occurrences of words in the text corpus. For  
209 example, 'coronavirus' → 'facility', 'effort': indicating policy efforts towards capacity building and  
210 healthcare facility management; 'coronavirus' → 'essential': extended focus on availing essential  
211 services during the lockdown period. 'mask' → 'measure'; the use of masks had been extensively  
212 promoted as a COVID-19 control measure in India and currently made compulsory by law. Similarly,  
213 'lockdown' of 1.3 billion people of India has been the stringent public policy measure that has been  
214 enforced to curve the spread of coronavirus. The higher weighed words/policy measures with the  
215 lockdown can be seen in darker shades of grey in Fig 1b.

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 Number: 1  
This has already been defined as PIB earlier in the report.

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## Topic models

We have individually analysed and modelled the content of press releases from different ministries by classifying them in 14 policy categories (see Table 1). In doing so, we estimated the approximate number of topic models for each of the policy categories using the benchmarking metrics of Arun2010 (23), CaoJuan2009 (24), Griffiths2004 (5) and Deveaud2014 (25), as illustrated in Table 3. The approximation of the number of topics was also made through judgement, where, we found that increasing the number of topics was affecting the interpretability of the topic models.

Table 2. Estimated topic models for each of the policy categories

| Sl. No. | Policy sectors       | Approximated number of topic models | Benchmarking criteria      |
|---------|----------------------|-------------------------------------|----------------------------|
| 1       | Agriculture and Food | 2                                   | CaoJuan2009; Deveaud2014   |
| 2       | AYUSH                | 2                                   | CaoJuan2009                |
| 3       | Chemicals            | 2                                   | CaoJuan2009                |
| 4       | Electronics & IT     | 4                                   | CaoJuan2009; Deveaud2014   |
| 5       | Health               | 4                                   | CaoJuan2009; Deveaud2014   |
| 6       | Home Affairs         | 10                                  | CaoJuan2009; Griffiths2004 |
| 7       | Labour & Commerce    | 9                                   | CaoJuan2009                |
| 8       | MHRD                 | 4                                   | CaoJuan2009; Deveaud2014   |
| 9       | PMO                  | 8                                   | Deveaud2014                |
| 10      | Power                | 3                                   | CaoJuan2009; Deveaud2014   |
| 11      | Science & Technology | 7                                   | CaoJuan2009; Griffiths2004 |
| 12      | Social Justice       | 2                                   | CaoJuan2009; Deveaud2014   |
| 13      | Transport            | 10                                  | CaoJuan2009                |
| 14      | Urban                | 7                                   | CaoJuan2009                |

High-frequency words within the ministries are illustrated in Fig 3. The policies on agriculture and farmer's welfare focussed on ensuring food security and undisrupted supply chain during the nationwide lockdown phase (see Fig 3). February to April is the harvesting time for winter crops in India that is crucial for food security in the country. In the wake of coronavirus and strict lockdown measures, the GoI allowed farmers to harvest. Besides, policy emphasis was laid on providing fiscal packages to the distressed farmers who were affected by national lockdown and supply chain disruption. Topic extraction through LDA (see Table 4) showed that the policy nudges were focussed on the continuity of harvest (topic 1, 'harvest',  $\beta = 0.030$ ) and rerouting of the critical food supply chain



Number: 1

What does this mean to have "modelled" the content.

241 (topic 2, 'lakh',  $\beta = 0.100$ ) during the extended lockdown period for ensuring food security (topic 1,  
 242 'food security',  $\beta = 0.150$ ).



Fig 3. High-frequency words in the official media releases of different ministries of the Government of India in the wake of COVID-19.

251 Table 3. Topic extracted by LDA as per the policy sectors

| Agriculture and Food |           |                 |           |                 |       |             |       |
|----------------------|-----------|-----------------|-----------|-----------------|-------|-------------|-------|
| Topic 1              | Prob. (β) | Topic 2         | Prob. (β) |                 |       |             |       |
| Food security        | 0.150     | Lakh            | 0.100     |                 |       |             |       |
| Agriculture          | 0.047     | Farmer          | 0.059     |                 |       |             |       |
| Lockdown             | 0.045     | Lockdown        | 0.030     |                 |       |             |       |
| Crop                 | 0.040     | Issue           | 0.025     |                 |       |             |       |
| Harvest              | 0.030     | Agriculture     | 0.018     |                 |       |             |       |
| AYUSH                |           |                 |           |                 |       |             |       |
| Topic 1              |           | Topic 2         |           |                 |       |             |       |
| AYUSH practice       | 0.070     | Traditional     | 0.035     |                 |       |             |       |
| Covid-19             | 0.040     | Ayurveda        | 0.032     |                 |       |             |       |
| Measure              | 0.035     | Immunity        | 0.030     |                 |       |             |       |
| Infection            | 0.030     | Preventive      | 0.029     |                 |       |             |       |
| Homeopathy           | 0.018     | Hygiene         | 0.032     |                 |       |             |       |
| Chemicals            |           |                 |           |                 |       |             |       |
| Topic 1              |           | Topic 2         |           | Topic 3         |       |             |       |
| Medicine             | 0.065     | Device          | 0.048     | Mask            | 0.048 |             |       |
| PM-CARES             | 0.030     | Medicine        | 0.045     | PPE             | 0.045 |             |       |
| Medical supply       | 0.028     | Medical supply  | 0.025     | Sanitiser       | 0.036 |             |       |
| Bulk supply          | 0.020     | PM-CARES        | 0.022     | Drug surplus    | 0.030 |             |       |
| Country              | 0.018     | Government      | 0.20      | India           | 0.023 |             |       |
| Electronics & IT     |           |                 |           |                 |       |             |       |
| Topic 1              |           | Topic 2         |           | Topic 3         |       | Topic 4     |       |
| Fake news            | 0.070     | Ministry        | 0.050     | Doordarshan     | 0.025 | Fake news   | 0.07  |
| Covid-19             | 0.05      | Fake news       | 0.050     | Episodes        | 0.020 | Security    | 0.055 |
| Government           | 0.045     | India           | 0.048     | Information     | 0.018 | People      | 0.048 |
| Ensure               | 0.038     | Social media    | 0.025     | Crisis          | 0.019 | Quarantine  | 0.040 |
| Telecast             | 0.015     | Media           | 0.020     | Country         | 0.015 | FCU         | 0.025 |
| MHRD                 |           |                 |           |                 |       |             |       |
| Topic 1              |           | Topic 2         |           | Topic 3         |       | Topic 4     |       |
| Student              | 0.08      | Student         | 0.079     | MHRD            | 0.08  | Work-home   | 0.040 |
| Online learning      | 0.057     | Parent          | 0.026     | Online learning | 0.034 | Online      | 0.038 |
| Education            | 0.044     | Time            | 0.018     | Institution     | 0.030 | Examination | 0.035 |
| Provision            | 0.041     | India           | 0.015     | Development     | 0.028 | Schools     | 0.020 |
| HRD                  | 0.028     | Nationwide      | 0.010     | NBT             | 0.025 | IIT         | 0.015 |
| Power                |           |                 |           |                 |       |             |       |
| Topic 1              |           | Topic 2         |           | Topic 3         |       |             |       |
| PM-CARES             | 0.015     | Stability       | 0.017     | REP             | 0.022 |             |       |
| PSU                  | 0.013     | Light off       | 0.015     | PM-CARES        | 0.013 |             |       |
| Covid                | 0.011     | Renewable       | 0.010     | MNRE            | 0.010 |             |       |
| Coal                 | 0.010     | Power           | 0.008     | Grid            | 0.007 |             |       |
| Supply               | 0.008     | Adequacy        | 0.005     | Stability       | 0.005 |             |       |
| Social Justice       |           |                 |           |                 |       |             |       |
| Topic 1              |           | Topic 2         |           |                 |       |             |       |
| Disability           | 0.032     | Self Help Group | 0.007     |                 |       |             |       |
| Migrant worker       | 0.027     | Woman           | 0.025     |                 |       |             |       |
| Ministry             | 0.025     | Lockdown        | 0.023     |                 |       |             |       |
| Social security      | 0.022     | NTFP            | 0.022     |                 |       |             |       |
| Pandemic             | 0.020     | Tribal          | 0.022     |                 |       |             |       |

252

253 AYUSH is an acronym for Ayurvedic, Yoga and Naturopathy, Unani, Siddha and Homeopathy.

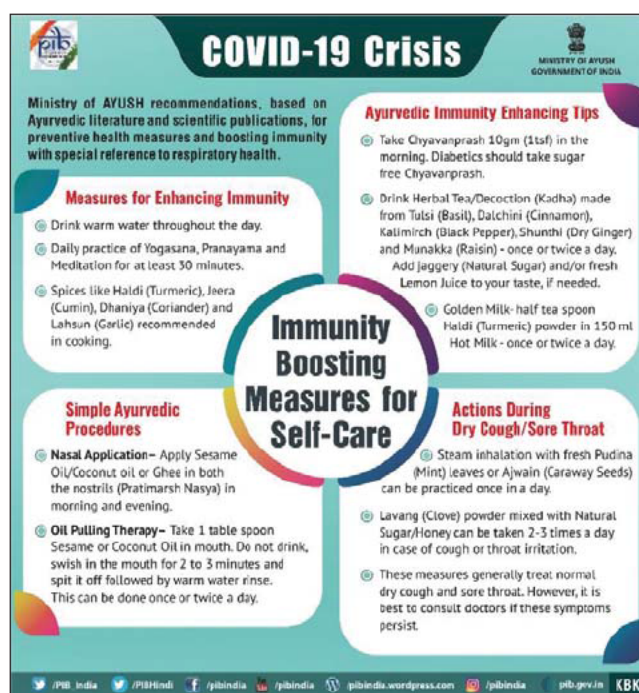
254 In the early stages of coronavirus pandemic in the country, this ministry released a series of press

255 releases nudging people to follow the traditional medicinal practice of Ayurveda and maintaining good

256 health and well-being through yoga (see Fig 3). The policy nudges, as revealed by the topic (see Table

4), showed a greater emphasis on increasing immunity through ayurvedic and herbal products. The topics also revealed higher stress on using Homeopathy ( $\beta = 0.018$ ) and Ayurveda ( $\beta = 0.032$ ) as preventive measure along with disciplined personal hygiene. It was observed that from the media releases that between January and the first week of March, AYUSH policies were aggressively nudging the use of traditional route to treat COVID-19. However, there was a shift in narrative during the mid-March as India experienced high infection rates. It focussed on promoting a healthy lifestyle through policy nudges using hashtags like #YOGAathome (see box 1).

Box 1. AYUSH nudges on preventive health measures and boosting immunity (source: (34))



The high-frequency word cloud for 'chemical' policy sector (see Table 1 and Fig 3) revealed higher policy stress on the availability of therapeutic drug and medical devices like ventilator and lifesaving equipment. Greater policy nudges were on empowering and motivating the manufacturing sector to contribute to medical device availability in the wake of coronavirus pandemic (see Fig 3). Three topic models were extracted that further expands on the policy nudges in this sector (see Table 4). Topic 1 indicates a greater emphasis on the bulk supply of medicine ( $\beta = 0.065$ ) and contribution to the PM-CARES fund to ensure medicine availability in the country. Topic 2 further illustrates the

aggressive nudging in manufacturing medical devices ( $\beta = 0.048$ ). In addition, LDA extracts in Topic 3 revealed the higher impetus on supporting the frontline workers, see 'mask ( $\beta = 0.048$ )', 'PPE (personal protective equipment) ( $\beta = 0.045$ )', 'sanitiser ( $\beta = 0.036$ )' and 'drug surplus ( $\beta = 0.030$ )' (see Table 4).

The nudges from electronics and IT related policies were aggressive on tackling fake news in social media and keeping people indoors during the lockdown (see Fig 3). The repeated telecast of popular '80s and '90s TV shows were one of the distinct public policy nudges. It used nostalgia as a nudge to make the people conform to stay at home norm and practice social distancing measures (35). These TV-shows ranged from family entertainer to religious and were broadcasted in the national channel called Doordarshan. Four topics were extracted (see Table 4), of which, topic 1 shows 'fake news' around COVID-19 as a high probability term ( $\beta = 0.070$ ). It is being treated as a concern of national security. Topic 2 showed a similar discourse on guidelines concerning social media usage ( $\beta = 0.025$ ) and fake news control ( $\beta = 0.050$ ) through the Ministry of Electronics & IT. As aforementioned, India's public broadcaster DD aired '80s epic Hindu tale 'Ramayana' and 'Mahabharata' as a self-quarantine measure (35). It is an application of nudging-based public policy measure referred to as the herd effect (29), illustrated in Topic 3 (see Table 4). Besides, various fiscal measures were taken to support the continuity of information flow through print and electronic media during the quarantine ( $\beta = 0.040$ ) period (see Topic 4, table 4). Fact-Checking Units (FCU) were set up to encourage the public to verify news for curbing fake news spread in social media (see Topic 4, table 4).

In lines with the Electronics & IT, aggressive nudging on online learning was done by the Ministry of Human Resource Development (MHRD) (see Fig 3 and Table 4). Four topics were extracted, where online learning (Topic 1 and Topic 3) and work from home (Topic 4,  $\beta = 0.040$ ) were the highest frequency words (see Table 4). The topic 1 illustrated the policy focus on infrastructure setup and provisioning of an online learning environment in the country. Subsequent nudging was done to the parents to encourage homeschooling by aggressively advertising the use of the National Digital Library of India, a Gol initiative under the National Mission on Education through Information and



298 Communication Technology (NMEICT). This digital resource provides access to a multilingual virtual  
299 repository of learning resources across different levels of education with a single-window search  
300 facility (see Topic 2 and Topic 3). Policy impetus was on expanding the online educational resources  
301 by leveraging information and communication technologies (ICT). It was extracted on Topic 3, that  
302 shows 'institutional' ( $\beta = 0.030$ ) and the National Book Trust (NBT) ( $\beta = 0.025$ ). Hashtags like  
303 #StayHomeIndiaWithBooks were created as policy nudges by the NBT of MHRD, in its efforts to  
304 encourage people to read books while at home, is providing its select and best-selling titles for free  
305 download as part of its initiative. The NBT also launched a 'Corona Studies Series' to encourage  
306 readership of scientific books on covid-19 to curb the spread of fake news. Similarly, policy nudges  
307 were made with #StayIN and #StayHome hashtags to encourage people to work from home (see Topic  
308 4,  $\beta = 0.040$ ).

309 The Ministry of Human Resource Development expansively nudged the start-up and  
310 innovation community in India to participate in the fight for COVID-19 by launching programs like  
311 'Fight Corona IDEathon. Moreover, Topic 4 also revealed the policy support provided on rescheduling  
312 national-level engineering and medical entrance examinations ( $\beta = 0.035$ ). Besides extending the  
313 school and higher education lockdown period, the MHRD also converted public-owned school and  
314 university buildings into makeshift hospitals for COVID-19 patients.

315 Policy nudges in the power and energy sector were mostly dedicated to collecting funds for  
316 PM-CARES (see Fig 3). The extracted topics are illustrated in Table 4. Topic 1 consists of 'coal' as a high  
317 probable word ( $\beta = 0.010$ ) that shows efforts in ensuring supply chain stability to thermal power plants  
318 in the country. Topic 2 further illustrates the concerns associated with the lockdown in the country  
319 with the 'lights off' request by the Prime Minister (PM) of India. The PM had nudged to the people to  
320 voluntarily switch off their lights for 10 minutes on April 5, 2020, as solidarity to frontline workers. It  
321 raised concerns of grid stability ( $\beta = 0.017$ ) and power adequacy ( $\beta = 0.005$ ). Power adequacy was also  
322 discussed through policy releases on renewable energy projects continuity even during the national

lockdown (see Topic 4, table 4). It can have a nudging impact on the post-COVID energy policies on decarbonisation and climate change mitigation.

Social justice in the wake of coronavirus pandemic is a critical policy focus point. Nudges included social security of migrant workers, labourers and women-led self-help group (see Fig 3). Particular guidelines were released for the person with a disability (see Table 4, Topic 1,  $\beta = 0.032$ ) and migrant workers stuck in cities amidst the nationwide lockdown ( $\beta = 0.027$ ). Topic 2 further illustrates the social protection policies for the tribal communities. They were affected by the national lockdown and its impact on their livelihood-based on Non-Timber Forest Products ( $\beta = 0.022$ ). Special fiscal packages were planned for the self-help group (SHG) run by rural women (see Topic 2,  $\beta = 0.022$ ).

Ministry of Home Affairs and Ministry of Defence are the institutions that deal with national security and peacekeeping. In this study, we combined the press releases of both the ministries as 'Home Affairs' (see Table 1) as they have been working in tandem governing the national lockdown rules in the wake of coronavirus pandemic. Fig 3 shows the high-frequency words from the home affairs. It exhibited ensuring the supply of essential commodities, ensuring lockdown governance, surveillance measures and quarantine facilities as highlighted words. Ten topic models were extracted using LDA, as illustrated in Table 5.

Table 4. Topic extracted by LDA for Home Affairs

| Home Affairs |                   |                |                   |              |                   |              |                   |
|--------------|-------------------|----------------|-------------------|--------------|-------------------|--------------|-------------------|
| Topic 1      | Prob. ( $\beta$ ) | Topic 2        | Prob. ( $\beta$ ) | Topic 3      | Prob. ( $\beta$ ) | Topic 4      | Prob. ( $\beta$ ) |
| India        | 0.140             | SupplyChain    | 0.100             | Government   | 0.080             | Lockdown     | 0.082             |
| Cadet        | 0.110             | AirDrop        | 0.059             | Lockdown     | 0.070             | Surveillance | 0.065             |
| Support      | 0.060             | Medical        | 0.030             | National     | 0.065             | Drones       | 0.060             |
| Border       | 0.055             | AirForce       | 0.025             | Restrictions | 0.050             | DRDO         | 0.040             |
| DRDO         | 0.053             | Defence        | 0.018             | Surveillance | 0.045             | Containment  | 0.034             |
| Topic 5      | Prob. ( $\beta$ ) | Topic 6        | Prob. ( $\beta$ ) | Topic 7      | Prob. ( $\beta$ ) | Topic 8      | Prob. ( $\beta$ ) |
| Spread       | 0.075             | Provide        | 0.121             | Tablighi     | 0.170             | Airport      | 0.160             |
| Hand         | 0.065             | SupplyChain    | 0.110             | Delhi        | 0.152             | Surveillance | 0.070             |
| Person       | 0.061             | Governance     | 0.093             | Spike        | 0.100             | Borders      | 0.055             |
| Devices      | 0.057             | EssentialItems | 0.073             | Lockdown     | 0.090             | Passenger    | 0.053             |
| PPE          | 0.050             | Railways       | 0.050             | Religious    | 0.051             | Checkpoint   | 0.050             |
| Topic 9      | Prob. ( $\beta$ ) | Topic 10       | Prob. ( $\beta$ ) |              |                   |              |                   |
| DRDO         | 0.100             | Defence        | 0.098             |              |                   |              |                   |
| R&D          | 0.066             | Hospital       | 0.064             |              |                   |              |                   |
| Masks        | 0.060             | Ventilator     | 0.061             |              |                   |              |                   |
| PPE          | 0.056             | Navy           | 0.060             |              |                   |              |                   |
| CriticalCare | 0.053             | Airforce       | 0.056             |              |                   |              |                   |



Topic 1 (see Table 5) illustrates the actions taken by the Indian defence in increasing surveillance of the borders ( $\beta = 0.055$ ) and the involvement of Defence Research and Development Organisation (DRDO) ( $\beta = 0.053$ ). Similarly, topic 2 shows the involvement of the Indian Air Force (IAF) ( $\beta = 0.025$ ) in ensuring the supply chain ( $\beta = 0.100$ ) of essential items amidst national lockdown. IAF planes were used to transport medicines, PPE, masks and life-saving devices across the nations (see Table 5). The Ministry of Home Affairs (MHA) is the decision-making body on ensuring lockdown and national security are maintained in the wake of the pandemic. Nudging was around extensive surveillance and ensuring public follow the restrictions (see Topic 3, table 5). The DRDO was also involved in extensive research and development of containment equipment ( $\beta = 0.034$ ). It included scaling up the technology for the use of aerial drones for surveillance ( $\beta = 0.065$ ). There was also extensive use of spatial mapping technologies for contact tracing amidst national lockdown.

The MHA was also extensively involved with the manufacturing sector to design and develop low-cost ventilators, PPE, sanitisers and masks (see Topic 5 and Topic 6, Table 5). Extensive nudging was done to ensure that the government was actively involved in delivering essential items by engaging with the supply chain of Indian Railways (see Topic 6). Moreover, amidst the national lockdown, spikes in coronavirus cases were observed in New Delhi due to religious gathering (Tablighi Jamaat congregation), the MHA had to tighten up surveillance and increase the nationwide contact tracing (see Topic 7). This event was speculated as to India's worst coronavirus vector (36).

Besides, MHA ensured surveillance at the airports and international borders and were the first responders during the early stage of the pandemic in the country (see Topic 8). It used nudging at the airport to ensure travellers maintain a 14-day home quarantine by stamping people with 'Home Quarantine 'on forearms (see Box 2).

363

Box 2. 'Home quarantined' stamp for travellers as nudging for self-isolation (source: (37))



364

365 Furthermore, Topic 9 and Topic 10 (see Table 5) indicated the efforts made in ensuring the  
366 availability of critical care infrastructure and PPE in remote parts of the country using National Cadet  
367 Corps (NCC). The National Cadet Corps, a Tri-Services Organisation, comprising the Army, Navy and  
368 Air Wing, engaged in grooming the youth of the country into disciplined and patriotic citizens. The  
369 cadets were deployed for various duties like traffic management, supply chain management,  
370 preparation and packaging of food items, distribution of food and essential items, queue  
371 management, social distancing, operating control centres and CCTV control rooms. Besides, NCC  
372 cadets were sensitising the public against COVID-19 by sending messages (as nudges) on social media  
373 platforms like Twitter, Instagram and WhatsApp, etcetera. They further enhanced the mental and  
374 social protection of migrant workers and people living in hyperdense settlements like slums by  
375 leveraging ICTs (38). Besides, the MHA worked closely with the Ministry of Finance to plan 'Economic  
376 Distress Relief Package' that involves instant relief in the form of providing a slew of measures that  
377 will ensure food grain and other essential as well as financial assistance to disadvantaged sections of  
378 the society.

379 The surveillance in urban areas was done using smart technologies (see Fig 3) that included  
380 drones, spatial analysis, low-power Bluetooth mobile phone applications and humanoid robots (39).  
381 The Smart City program of India (40) has been leveraged as critical vantage points in the COVID-19  
382 fight by the Ministry of Housing and Urban Affairs (MoHUA) (41). For example, helium balloon  
383 attached with cameras for surveillance on lockdown violators were used in the Vadodara Smart City,

Gujarat. A COVID-19 War Room at Bengaluru was established to enable real-time data-driven decision-making using a single dashboard. Similarly, tele-video consultation facilities were launched in Agra to enable E-Doctor Service for the local population (41). See Table 6 for the topics extracted by LDA concerning urban policies.

Table 5. Topic extracted by LDA concerning urban sector

| Urban            |                   |                 |                   |            |                   |              |                   |
|------------------|-------------------|-----------------|-------------------|------------|-------------------|--------------|-------------------|
| Topic 1          | Prob. ( $\beta$ ) | Topic 2         | Prob. ( $\beta$ ) | Topic 3    | Prob. ( $\beta$ ) | Topic 4      | Prob. ( $\beta$ ) |
| Virus            | 0.050             | Smart           | 0.021             | Quarantine | 0.028             | Various      | 0.030             |
| Track            | 0.030             | Technology      | 0.015             | Monitor    | 0.035             | Technologies | 0.040             |
| Spread           | 0.070             | Surveillance    | 0.030             | Dashboard  | 0.030             | Public       | 0.030             |
| Public           | 0.040             | Control         | 0.048             | Citizen    | 0.040             | Identify     | 0.045             |
| Monitor          | 0.050             | City            | 0.180             | App        | 0.100             | City         | 0.040             |
| Topic 5          | Prob. ( $\beta$ ) | Topic 6         | Prob. ( $\beta$ ) | Topic 7    | Prob. ( $\beta$ ) |              |                   |
| Vehicles         | 0.075             | Sanitise        | 0.030             | Track      | 0.004             |              |                   |
| Spatial analysis | 0.065             | Monitor         | 0.036             | Smart      | 0.003             |              |                   |
| Municipal        | 0.061             | Mobile          | 0.040             | GIS        | 0.003             |              |                   |
| Government       | 0.057             | Essential items | 0.050             | Near-me    | 0.005             |              |                   |
| City             | 0.050             | Citizens        | 0.110             | Urban      | 0.003             |              |                   |

Box 3. (a) A drone used by police to monitor activities of people and spread awareness announcements; (b) A motorist rides through a disinfection tunnel (source: (41,42))



The significant policy nudges were on requesting the public to comply with the strict quarantine rules using drones and smart surveillance technologies (see Table 6 and Box 3a). Nudging was also on the use of COVID-19 contact tracing apps, and GIS-based methods for monitoring quarantined public at a municipality level. Special attention was given to the routine solid waste collection, transportation and disposal activities along with cleaning and scrapping were carried out efficiently to keep the cities clean. In few highly dense urban centres, disinfection tunnels were installed (see Box 3b) with facilities of thermal screening by taking temperature. Pedestal operated

hand-wash and soap dispenser, mist spray of sodium hypochlorite solution and hand dryer facility.

The topic extracted in table 6 compiles all these measures to control the spread of COVID-19.

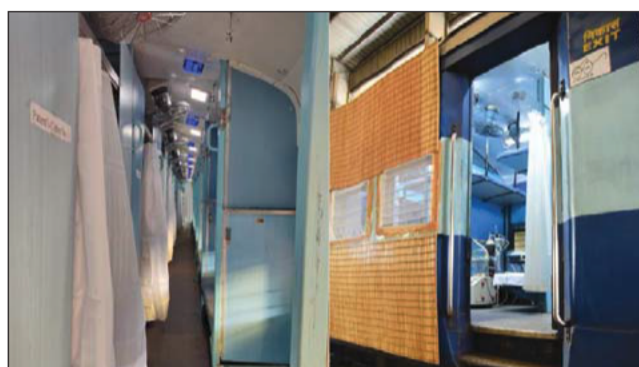
The transportation sector played a critical role in maintaining the supply chain of essential items. Fig 3 shows the high-frequency words in the transportation sector that includes freight transport, railways, shipping and road and highways. The topics extracted by LDA is illustrated in table 7 with the policy nudges in the transportation sector in the wake of coronavirus pandemic in India.

Table 6. Topic extracted by LDA in the transport sector

| Transport      |                   |   |                   |   |
|----------------|-------------------|---|-------------------|---|
| Topic 1        | Prob. ( $\beta$ ) | Topic 2   | Prob. ( $\beta$ ) | Policy nudges   |
| India          | 0.160             | Train   | 0.100             | Indian railways played a major role in ensuring supply chain of essential items are operated in business-as-usual conditions amidst the national lockdown. Extensive nudging was done by the Ministry of Railways ensuring public that all there won't be any food or medicine shortage. It was repeatedly done to reduce public hysteria and mass panic. |
| Lockdown       | 0.150             | People  | 0.059             |   |
| Supply         | 0.100             | Railway   | 0.030             |   |
| Medical        | 0.050             | SupplyChain   | 0.025             |   |
| Railway        | 0.080             | Lockdown  | 0.018             |   |
| Topic 3        |                   | Topic 4   |                   | Nudges were by the railway factories where they started to produce PPE and masks to curb national shortage for frontline workers. Railways rerouted several long-distance trains to support remote hospitals with lifesaving equipment and PPE.   |
| Issue          | 0.070             | Railway   | 0.160             |   |
| Needy          | 0.065             | Commodity   | 0.060             |   |
| Zone           | 0.055             | Masks   | 0.050             |   |
| Health         | 0.050             | PPE   | 0.050             |   |
| Hospital       | 0.048             | Factory   | 0.040             |   |
| Topic 5        |                   | Topic 6   |                   | During lockdown, supply chain of essential commodities was maintained through freight carriers by road and railways. Old trains were converted to isolation wards using frugal innovation in the wake of exponentially rising coronavirus cases (see Box 4).  |
| Supply         | 0.095             | Passenger   | 0.100             |   |
| Freight        | 0.090             | Effort  | 0.100             |   |
| Lockdown       | 0.075             | Wagon   | 0.080             |   |
| Load           | 0.060             | Makeshift   | 0.076             |   |
| Carry          | 0.050             | Cabin   | 0.060             |   |
| Topic 7        |                   | Topic 8   |                   | The Ministry of Civil Aviation operating cargo planes with passenger airlines, Indian Navy and Indian Airforce to deliver medicine and testing kits to remotest part of the country. Public nudging was done through the term 'Lifeline UDAAN' indicating the aforementioned flights supplying essential items.   |
| UDAAN          | 0.200             | Flights   | 0.250             |   |
| Flights        | 0.100             | Provide   | 0.050             |   |
| Emergency      | 0.055             | Navy  | 0.030             |   |
| AirForce       | 0.040             | Emergency   | 0.020             |   |
| Medical        | 0.030             | Shelter   | 0.011             |   |
| Topic 9        |                   | The Ministry of Shipping started 100% surveillance by installing thermal screening, detection and quarantine systems immediately for disembarking Seafarers or Cruise Passengers. Safety procedures were made compulsory while handling cargo at ports. |                   |   |
| Port           | 0.110             |   |                   |   |
| Shipping       | 0.100             |   |                   |   |
| Cargo          | 0.075             |   |                   |   |
| Covid          | 0.070             |   |                   |   |
| Screening      | 0.056             |   |                   |   |
| Topic 10       |                   | Railways nudged public by issuing 100% refund on cancellation of tickets to discourage travel in the wake of covid-19 pandemic. In addition, they removed all senior citizen benefits and concessions to discourage ticket sales.                       |                   |   |
| Railway        | 0.300             |   |                   |   |
| Refund         | 0.080             |   |                   |   |
| Tickets        | 0.050             |   |                   |   |
| Senior Citizen | 0.030             |   |                   |   |

408

Box 4. Indian Railways converted old trains into isolation wards (source: (43))



409

410 In the wake of coronavirus, the Government of India consistently nudged the scientific  
 411 community of India to fight the pandemic by launching a series of funding through the Department of  
 412 Science and Technology (DST). Policy design relied on evidence-based decision-making. High-  
 413 frequency keywords concerning Science and Technology (S&T) sector is illustrated in Fig 3. The topics  
 414 extracted by LDA on S&T is illustrated in Table 8.

415 Table 7. Topic extracted by LDA for the Science and Technology (S&amp;T) sector

| Science and Technology |                   |             |                   |   |
|------------------------|-------------------|-------------|-------------------|---|
| Topic 1                | Prob. ( $\beta$ ) | Topic 2     | Prob. ( $\beta$ ) | Policy nudges   |
| Develop                | 0.110             | Test        | 0.150             | Policy nudges were on the development of affordable rapid testing kits, PPE, medical devices and infection preventive technologies.<br>Office of the Principal Scientific Advisor to the Government of India extensively nudged public to adopt homemade masks and adhere to frequent hand washing to curb the spread of coronavirus (44).        |
| Health                 | 0.070             | Mask        | 0.120             |   |
| Facility               | 0.050             | DST         | 0.040             |   |
| Time                   | 0.030             | Patients    | 0.050             |   |
| Rapid                  | 0.028             | Hand wash   | 0.060             |   |
| Topic 3                |                   | Topic 4     |                   |   |
| India                  | 0.160             | Technology  | 0.160             | Private sector R&D institutions and industry were nudged to join the fight against covid-19. Government urged them to develop highly scalable technologies and testing kits to ramp up national testing. Use of technology to ensure strict lockdown was also nudged by DST.  |
| Covid                  | 0.080             | NIV         | 0.050             |   |
| Technology             | 0.040             | Hospital    | 0.050             |   |
| Effort                 | 0.040             | Help        | 0.030             |   |
| Industry               | 0.040             | Proposal    | 0.030             |   |
| Topic 5                |                   | Topic 6     |                   |   |
| Research               | 0.120             | Science     | 0.120             | R&D of low-cost rapid testing kits were nudged from the Office of the Principal Scientific Advisor to the Government of India. Extensive nudging was also done to the public to install a government approved contact tracing app called 'AarogyaSetu'. Call for research proposals and innovation challenges were launched to fight coronavirus. |
| Solution               | 0.090             | AarogyaSetu | 0.090             |   |
| Diagnostickit          | 0.050             | Innovation  | 0.070             |   |
| Patient                | 0.050             | Funding     | 0.050             |   |
| Covid                  | 0.030             | Vaccine     | 0.030             |   |
| Topic 7                |                   |             |                   |   |
| Infection              | 0.110             |             |                   | The DST also nudged micro, small and medium scale industries (MSMEs) and rural enterprises to produce large-scale PPE and masks. It was done to ramp up the PPE, masks and sanitiser production in rural areas that could keep the economy running.   |
| Research               | 0.060             |             |                   |   |
| Development            | 0.060             |             |                   |   |
| PPE                    | 0.040             |             |                   |   |
| Masks                  | 0.030             |             |                   |   |

416

The National Institute of Virology (NIV) was at the forefront of testing, which provided the technical guidance for testing labs across the country (see Table 8). Academic and research institutions were encouraged to submit competitive interdisciplinary research proposals to focus on the development of affordable diagnostics, vaccines, antivirals, disease models, and other R&D to study COVID-19 (see Table 8).

Scientific innovation during this period includes robots for encouraging social distancing in public spaces and healthcare centres (see Box 5). A contact tracing app (AarogyaSetu) using GPS and Bluetooth to inform people when they are at risk of exposure to COVID-19. Low-cost, easy-to-use, and portable ventilators that can be deployed even in rural areas of India. To nudge people into using the application was provided by frequent reminders through SMS. Innovations were also done in ensuring public-space hygiene through the development of water-based sanitiser disinfectant and technology to dispense ionised water droplets to oxidise the viral protein (45). The DST set up a task force to map technologies developed by start-ups related to COVID-19. It is funding start-ups to develop relevant innovations such as rapid testing for the virus (see Table 8). The national government launched the COVID-19 solution challenge on March 16 that invited innovators to offer ideas and solutions for tackling the pandemic. It was a policy nudge on crowdsourcing ideas that encouraged public and the start-up ecosystem to contribute to this fight. BreakCorona is one such crowdsourced initiative that received 1,300 ideas and 180 product solutions within two days of launch (45). An online crowdsourced portal called Coronasafe-Network, was also set-up by volunteers to provide real-time open-source, public platform containing details on COVID-19 precautions, tools and responses which serves as a useful starter-kit for innovators (45).



439

Box 5. Robot dispensing sanitiser in isolation wards in a hospital in Chennai, India (source: (46))



440

441 Table 8. Topic extracted by LDA for health sector

| Health            |           |              |           |            |          |               |          |
|-------------------|-----------|--------------|-----------|------------|----------|---------------|----------|
| January           |           |              |           |            |          |               |          |
| Topic 1           | Prob. (β) | Topic 2      | Prob. (β) | Topic 3    | Prob.(β) | Topic 4       | Prob.(β) |
| Report            | 0.035     | Preparedness | 0.032     | Health     | 0.058    | Health        | 0.040    |
| China             | 0.022     | Report       | 0.023     | Ministry   | 0.058    | Screening     | 0.020    |
| nCoV              | 0.021     | Travel       | 0.020     | Airport    | 0.040    | Restriction   | 0.020    |
| Passenger         | 0.020     | Review       | 0.020     | Review     | 0.030    | Airport       | 0.018    |
| Airport           | 0.019     | Ministry     | 0.020     | Screening  | 0.020    | China         | 0.015    |
| February          |           |              |           |            |          |               |          |
| Topic 1           |           | Topic 2      |           | Topic 3    |          | Topic 4       |          |
| Health            | 0.070     | Passenger    | 0.045     | Advisory   | 0.043    | Travel        | 0.045    |
| Travel            | 0.050     | Health       | 0.042     | Government | 0.040    | Restrictions  | 0.040    |
| China             | 0.050     | State/UT     | 0.038     | Screen     | 0.035    | Passenger     | 0.032    |
| Welfare           | 0.040     | Airport      | 0.032     | Flights    | 0.030    | Surveillance  | 0.031    |
| Screening         | 0.030     | nCoV         | 0.030     | nCoV       | 0.028    | International | 0.030    |
| March             |           |              |           |            |          |               |          |
| Topic 1           |           | Topic 2      |           | Topic 3    |          | Topic 4       |          |
| India             | 0.052     | Passenger    | 0.065     | Country    | 0.070    | Test          | 0.054    |
| Health            | 0.051     | Screening    | 0.050     | Ministry   | 0.055    | PPE           | 0.050    |
| Safety            | 0.040     | Travel       | 0.050     | Health     | 0.042    | Healthcare    | 0.045    |
| Hospital          | 0.038     | Restriction  | 0.040     | ICMR       | 0.040    | Management    | 0.040    |
| Preparedness      | 0.020     | Health       | 0.038     | Research   | 0.038    | Lockdown      | 0.035    |
| April             |           |              |           |            |          |               |          |
| Topic 1           |           | Topic 2      |           | Topic 3    |          | Topic 4       |          |
| Ministry          | 0.080     | Management   | 0.075     | Health     | 0.075    | Country       | 0.080    |
| Lockdown          | 0.048     | PM           | 0.038     | Briefing   | 0.063    | Masks         | 0.030    |
| Social distancing | 0.045     | Essential    | 0.035     | PPE        | 0.030    | Pandemic      | 0.025    |
| Hospital          | 0.030     | Medicine     | 0.030     | Testing    | 0.025    | Testing       | 0.022    |
| Testing           | 0.028     | Testing      | 0.025     | Quarantine | 0.020    | Hygiene       | 0.020    |

442

443

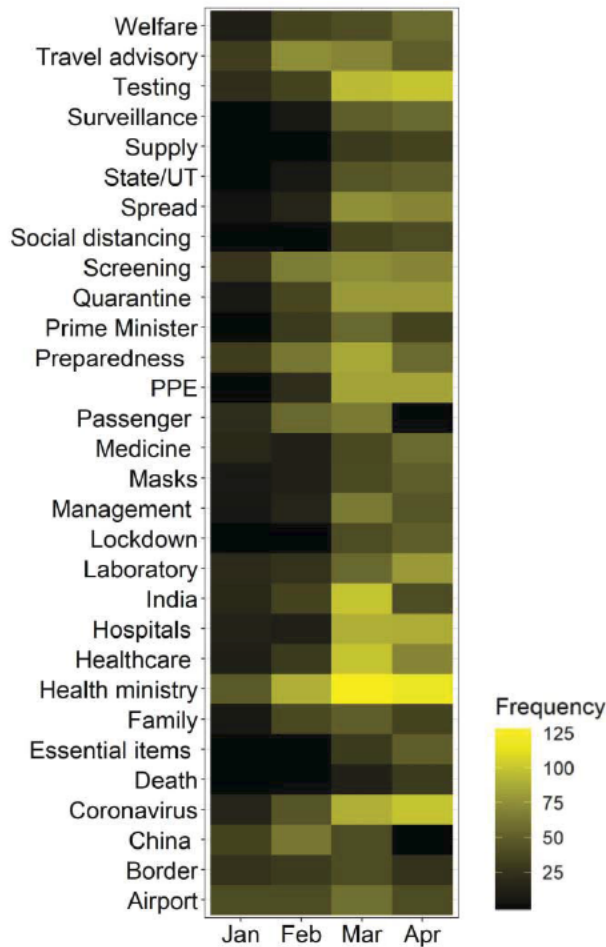


Fig 4. Temporal high-frequency word dynamics in the health policy in the wake of COVID-19 in India.

Table 9 shows the topic extracted by LDA in the health sector between January to April. The results show that in January, the policy nudges were in evaluating the risk of incoming travellers coming from China and extending surveillance at international airports. High-frequency words associated with such nudges can be seen in Fig 4. The change in policy narratives of the health ministry can be seen with the spread of infection in the country (see February, Table 9). The nudges were on enhancing thermal screening at airports of international arrivals and imposing travel restriction (see Fig 4).

Furthermore, topics extracted for February also indicates the beginning phase off restrictions such as advisory on social distancing and frequent hand washing as a possible preventive measure of towards COVID-19 infection (see Table 9). In additions, the Ministry of Health & Family Welfare



456 (MoHFW) began extensive nudging states and union territories of India to follow norms on social  
457 distancing and thermal screening of international travellers. More travel restrictions were imposed  
458 for China, Iran, Spain and Italy.

459 By March, the policy narratives shifted to imposing hard restrictions on travel, and people  
460 were discouraged from visiting crowded and public spaces. Strict social distancing nudges were being  
461 imposed as reactive policy. At the same time, MoHFW began to increase testing capacity across the  
462 country and on March 25, 2020, Phase 1 of lockdown began. People were nudged constantly during  
463 this phase to strictly adhere to the lockdown rules, use masks and wash hand frequently.  
464 Manufacturing units were asked to produce PPE, hand sanitiser and masks to meet the national  
465 demand (see Table 9, March). The Indian Council of Medical Research (ICMR) was the nodal agency  
466 for coordinating with press and MoHFW concerning the development regarding COVID-19 pandemic.  
467 It started daily briefing on government policies and preparedness on fighting coronavirus (see March,  
468 Table 9 and Fig 4).

469 The policy nudges for April was centred towards strengthening the COVID-19 specific  
470 healthcare requirements. Increasing the number of testing done per 1000 people was one of the  
471 significant agenda along with the social distancing measures. This phase was also marked by  
472 innovation in indigenous science and technology for empowering frontline working to fight COVID-19  
473 (see Table 8 and Table 9). During this period, policy nudges were also towards ensuring food security  
474 and availability of essential items and medicines across the nation (see Fig 4). Masks were made  
475 compulsory at public spaces across the nation (see Table 9, April and Fig 4).

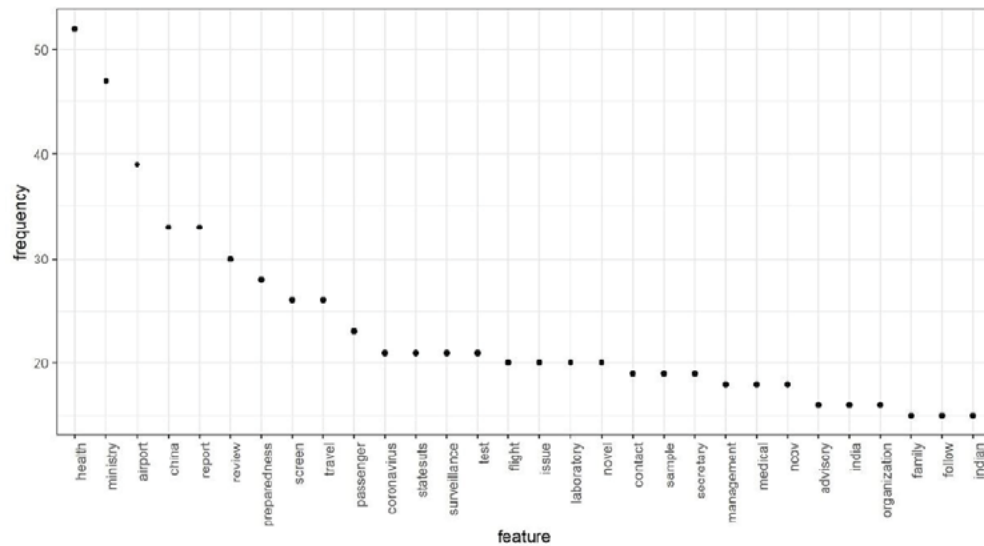


Fig 5. Keyword distribution for the Prime Minister's Office (PMO), Government of India.

Prime Minister's Office (PMO) was at the forefront of the fight against coronavirus, the high-frequency words are illustrated in Fig 5. Prime Minister Narendra Modi's nudges were driving the COVID preparedness, action and mitigation strategies in the country. His frequent public appearance was the most significant factor that created nudges in keeping a country of 1.3 billion people under strict lockdown and social distancing measures (see Table 10). In this process, the PMO spearheaded the creation of 'Prime Minister's Citizen Assistance and Relief in Emergency Situations Fund' (PM CARES Fund) for dealing with emergency or distress situation like posed by Covid-19 pandemic. PM-CARES was created to nudge the public into micro-donations and show the strength of public participation to mitigate any issue. Most of the nudges were in the form of social media advertisements, SMS forwards and repeated reminders through broadcasting media.

The PMO was created 'Covid-19 Economic Response Task Force' to deal with the economic challenges caused by the pandemic. Prime Minister (PM) also nudged the business community and higher-income groups to look after the economic needs of those from lower-income groups, from whom they take various services, urging them not to cut their salary on the days they are unable to render the services due to inability to come to the workplace. PM stressed on the importance of humanity during such times (47). The topics extracted by LDA on PMO is illustrated in Table 9.

494 Table 9 Topic extracted by LDA for Prime Minister's Office

| Prime Minister's Office |                   |               |                   |   |
|-------------------------|-------------------|---------------|-------------------|---|
| Topic 1                 | Prob. ( $\beta$ ) | Topic 2       | Prob. ( $\beta$ ) | Policy nudges   |
| Country                 | 0.250             | Step          | 0.100             | PM nudged the citizens of India to join the fight against coronavirus and stand up to the challenge in solidarity with the frontline workers. The nudges were on building mental strength as an Indian citizen and set examples of humanity. PM urged the people of India to be proud of the frontline workers and support the cause by donating it to PM-CARES.  |
| PM Modi                 | 0.160             | Citizen       | 0.080             |   |
| India                   | 0.150             | Family        | 0.079             |   |
| Coronavirus             | 0.080             | Challenge     | 0.075             |   |
| Ministry                | 0.050             | Medical       | 0.060             |   |
| Topic 3                 |                   | Topic 4       |                   |   |
| PMO                     | 0.160             | People        | 0.160             | PM assured the nation on economic policy in challenging times. He announced a USD 23 billion support measure for the welfare of the people of India. His nudges were also to higher income group and the business community to the economic needs of those from lower-income groups. In this effort, PM also nudged the leaders from various countries, especially SAARC, G-20, and BRICS nations to contribute to joint funding for fighting covid019 in South-East Asia.  |
| Economic                | 0.080             | World         | 0.050             |   |
| Crisis                  | 0.040             | Meet          | 0.050             |   |
| Impact                  | 0.040             | Fund          | 0.030             |   |
| PM-CARES                | 0.040             | International | 0.030             |   |
| Topic 5                 |                   | Topic 6       |                   |   |
| Pharma                  | 0.120             | AYUSH         | 0.120             | PM nudged the pharma sector to maintain a regular supply of medicines and medical equipment. He urged the pharma industry and the broader scientific community of India to work on diagnostic kits and possible vaccine agent for coronavirus. He nudged them that it is essential to maintain the supply of essential medicines and prevent black marketing and hoarding. Besides, PM also nudged the general public to install the AarogyaSetu contact tracking app and improve wellbeing and general immunity through Ayurveda. He promoted #YogaAtHome to de-stress the mind and strengthen the body during this challenging phase. |
| Solution                | 0.090             | AarogyaSetu   | 0.090             |   |
| Science                 | 0.050             | Handwash      | 0.070             |   |
| Pandemic                | 0.050             | Mask          | 0.050             |   |
| Innovation              | 0.030             | Wellbeing     | 0.030             |   |
| Topic 7                 |                   | Topic 8       |                   |   |
| Social distancing       | 0.080             | Frontline     | 0.200             | PM thanked the medical fraternity for its selfless service to the nation as the frontline defence against coronavirus. He assured that the security of frontline workers is of utmost importance, and the government will take every step to protect them. He nudged the state and union territories to step up their governance in the fight towards COVID-19 by assuring strict lockdown and social distancing measures.  |
| Lockdown                | 0.060             | Medical       | 0.160             |   |
| Fight                   | 0.150             | Workers       | 0.110             |   |
| State/UT                | 0.090             | Security      | 0.050             |   |
| Governance              | 0.070             | Law           | 0.050             |   |

495

#### 496 4. Discussion

497 We studied the reactive public policies in India in the wake of coronavirus pandemic through  
 498 topic modelling using LDA. The reactiveness of public policies across the policy sectors (see Table 1)  
 499 was done through the lens of nudge theory. The extracted topic models (TM) by an unsupervised  
 500 machine learning method called Latent Dirichlet Allocation (LDA) aided in gaining deeper insights into  
 501 the nudges made by various policymaking bodies (illustrated through Table 4 to Table 9). Besides, we  
 502 have analysed the high-frequency words (see Fig 3) to have a better bird's eye view of the public policy  
 503 focus points in the wake of COVID-19 in India.

504 High probability ( $\beta$ ) words across 14 policy sectors (see Table 1) illustrated the heuristics of  
 505 policymaking in containing the virus spread. The extraction of heuristics revealed that commonalities

in policy nudges were on enforcing lockdown rules, improving surveillance and encouraging the public to wear masks and wash hands frequently. Sector-specific heuristic focussed on maintaining equilibrium within the sector. For example, in the agriculture sector, a critical nudge on allowing the harvest of winter crops for food security amidst lockdown (see Table 4, Agriculture and Food, Topic 1). Heuristics were also extracted in the traditional medicine and well-being sector, that nudged people with #YogaAtHome and Ayurveda for immunity boosting (see Box 1). These nudges were also towards promoting a healthier lifestyle through traditional medicines and practices, that will be important even in post-COVID scenarios.

The public policy nudges in the chemical sector were on ensuring drug surplus, whereas more nudges were given to the industry to fulfil the shortage of medical devices and ventilators. Preservation of the medical supply chain was a critical heuristic. However, the coronavirus pandemic further created a demand for an efficient supply chain of personal protective equipment (PPE), sanitiser and masks (see Table 4, Chemicals). In doing so, new heuristics were added by nudging rural micro, small and medium enterprises (MSMEs) to join the fight against coronavirus by mass-producing PPE and masks. It had critical social justice implications, especially in rural areas where women-led self-help groups are the primary workforce in such MSMEs (see Table 4, social justice). Nudges on the use of AYUSH-based herbal and traditional products also catered to this rural SME ecosystem which is critical for the survival of the economy in the pandemic.

Besides, the populist Prime Minister (PM) frequently nudged the nation on staying at home, adhering to lockdown rules, improving immunity through yoga and Ayurveda and contributing to the PM-CARES fund (see Table 9). A herd effect was created through such nudges where public participation and micro-donations led the fight against Covid-19. Similar nudges for micro-donations through herd effect was also seen in other critical sectors like the manufacturing, commerce, power, construction and pharma.

Topic extractions also showed herd effect-based policies in the education sector, especially with a higher emphasis on online learning and #StayHomeWithBooks initiatives by the Ministry of Human Resource Development (see Table 4, MHRD). Public broadcasters began to air 80s epic Hindu-epic for herd effect on staying at home with family. Nudges through ‘nostalgia’ was a significant reactive policy step by the Ministry of Information and Broadcasting (see Table 4. Electronics & IT) to motivate self-isolation. Reactive policies were also seen in the urban sector that nudged municipal authorities to leverage smart technologies like drones for disinfection and surveillance, GIS-platforms and contact tracing apps (see Table 5 and Box 3).

A herd-effect was also created in the science and technology (S&T) community of India through funding R&D of diagnostic kits, disinfectant coating, crowdsourcing ideas and innovation challenges (see Table 7). Health sector policies focused on aggressive nudging the public to wear homemade masks, maintain social distancing and adhere to hand hygiene rules (see Table 8). The herd-effect was on sensitising people on the severity of Covid-19 transmission for 1.3 billion people.

The Indian Railways acted as a lifeline in ensuring the resilience of the supply chain of essential goods and rapid infrastructure development by converting old trains into isolation wards (see Box 4 and Table 6). Similarly, the Ministry of Defence and Ministry of Civil Aviation showed reactive policies through joint operations on-air delivery of essential medicine and devices through ‘Lifeline UDAAN’ mission (see Table 6). It created a herd effect on food and medicine security amongst the public that in turn prevented from hoarding on to essential goods. A critical heuristic in ensuring public follows the national lockdown norms that enabled the efforts of Ministry of Home Affairs (see Table 4).

Our LDA application identifies the herd-effects and policy nudges that can aid in lockdown easement planning, as aforementioned. Similar nudge-based policy approach is especially crucial in a democracy in India with a vast demographic and geo-spatial divide.

## 5. Conclusion

This study showed an application of topic modelling for public policy. Our application of LDA on government press releases extracted topics across core policy sectors in India that acted as critical nudges in the wake of coronavirus. Use of LDA in such media-data based policy analysis showed its strength in extracting topics that have high concordance with the broader narrative of the government. Our analysis showed that these narratives and nudges created herd effects that motivated the nation of 1.3 billion people to stay home during the national lockdown, even with high economic and social costs.

The integration of computational social science tools like the LDA for identifying nudges for channelising public behaviour through reactivity of public policy in the wake of coronavirus outbreak expands the scope of machine learning and AI for public policy applications. From a behavioural public policy perspective, the stochastic interpretation of the topic models through LDA derived critical policy heuristics that must be leveraged during the lockdown easing planning. We believe we are the first in applying LDA to account the reactivity of Covid-19 induced public policy at multi-sectoral scale. The key conclusions that can be drawn from this study are:

- The use of rigorous media campaigns primarily generated the herd behaviour for successful containment of COVID-19, frequent reminders through SMS, publicising data-driven risk maps generated from innovation grants, public reassurances by the medical community and invoking the feeling of nationalism and solidarity.
- Most of the interventions were targeted to generate endogenous nudges by using external triggers which potentially produces lasting desired behaviour in repeat settings (i.e. repeated broadcasting of information through multi-media channel) and hence can be applied in toto for future challenges.
- Prime Minister's frequent public appearances and assurances nudged in creating the herd effect across pharma, economic, health and public safety sectors that enabled strict national lockdown.

It created a herd effect of public participation and micro-donations to the PM-CARES fund to fight the pandemic.

- Successful herd effect nudging was observed around the public health sector (e.g., compulsory wearing of masks in public spaces; Yoga and Ayurveda for boosting immunity), transport sector (e.g., old railway coaches converted to isolation wards), micro, small and medium enterprises (e.g., rapid production of PPE and masks for frontline workers), science and technology sector (e.g., the rapid development of indigenous diagnostic kits, use of robots and nano-technology to fight infection), home affairs (e.g., people adhering to strict lockdown rules even at high economic distress), urban (e.g., drones, GIS-mapping, crowdsourcing) and education (e.g., work from home and online learning).
- Similar nudging-based approach to the public policy during lockdown easement planning can aid in the smooth yet staggered transition to normalcy. It can even provide a way forward for reviving the economy and climate change mitigation goals in post-COVID era.
- LDA can extract topics that have high concordance to nudges making it a suitable tool to study reactivity of behavioural public policies.

While this study showed the application of topic models in reactive public policy analysis, the inherent limitations of unsupervised topic modelling remain in the analysis. It interprets the topic models sensitive to the viewpoint of the analysts. Besides, the official press releases used in this study as the primary dataset may contain confirmatory biases, removal of such biases was beyond the scope of this study. Moreover, the press releases in the Press Information Bureau platform lacked granularity as they are intended for informing the public and media. In our future work, we are exploring the detailed policy documents to improve the clarity of topic models by sector.

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## 609 **Author Contributions**

610 All authors have contributed equally.

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