Article

Need for Policy Reforms in the Aftermath of COVID-19? An Analysis of Indian Pharmaceutical Sector

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Abstract

Acknowledging coronavirus disease 2019 (COVID-19) as a persistent health challenge in the foreseeable future, there is a need to evaluate how India can emerge as a major exporter in this category. This analysis with 41 COVID-19-related pharmaceutical products indicates that India currently lacks comparative advantage in several categories, for example, active pharmaceutical ingredient, medical equipment and devices, disinfectants and sterilisation products, and personal protective equipment. The country, however, enjoys a comparative advantage in manufacturing vaccines and formulations. Interestingly, India imposes higher tariffs and non-tariff measures (NTMs) on both sets of products, irrespective of the comparative advantages. Additionally, the article identifies important operational, logistic, and financial issues that can improve the efficiency of the pharmaceutical supply chain (PSC), which in turn can ensure smoother availability of these pharmaceutical products in the domestic market. While the operational issues underline the need for better coordination between multiple stakeholders, the logistic bottlenecks call for a general improvement at the infrastructure level. The financial issues correspond to infrastructural bottlenecks, transport costs and resulting cost escalation. The article concludes that the policymakers need to focus on the reduction of import barriers and improve the PSC to ensure the easier availability of COVID-19 medicines, vaccines, and related products.

Keywords

COVID-19, India, trade in medical products, competitiveness, tariffs and non-tariff measures, pharmaceutical supply chain

JEL Codes: F13, F15, I18, O25

Introduction

The coronavirus disease 2019 (COVID-19) pandemic caused an unprecedented health crisis in the world, and India was no exception. The country was severely hit by the unexpected arrival of the second wave

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of COVID-19 during the April-May months of 2021, both in terms of scale and reported fatalities.[1] While an ailing healthcare system resulting from a lack of hospital beds and apparatus, compounded by an understaffed and underskilled health workforce posed a major challenge, India also faced a severe shortage of COVID-19 vaccines, medicines, medical equipment and oxygen cylinders during early 2021 (Kapoor et al., 2020). This led to a major focus not only on the production enhancement but also on the administration of pricing and availability of vaccines (Supreme Court of India, 2021). To tackle the impending shortfall, India attempted to ensure domestic supply through export restrictions as a short-run measure (Government of India [GOI], n.d.). For easing supply in the short run, along with several developing countries, India also submitted a proposal to World Trade Organization (WTO), calling for a waiver from certain provisions of the Intellectual Property Rights (IPR) (Banik & Chakraborty, 2021). However, the developed countries in general and the European Union in particular, are presently not keen on the IPR waiver proposal (European Union, 2021).

The third wave of COVID-19 reached India in early 2022, and the country braced for the event appropriately through a well-prepared strategy (National Institute of Disaster Management, 2021). As a warning signal, the possibility of future COVID-19 waves has been acknowledged by various studies (SACMC, 2021). In this scenario, two major routes can be adopted by India to deal with any potential shortage in supply. The first can be implemented through a targeted foreign trade policy. While import tariff reforms can provide instant relief for consumers, planning for long-term capacity development and export promotion can ensure specialisation benefits. During the second wave in India, imports relieved the pressure on excess demand in the domestic market, notably in the case of liquid oxygen (Raghunandan, 2021). Additionally, India imported a large quantity of personal protective equipment, ventilators and testing kits from China, Germany, South Korea, Italy and the United States of America (USA) (Sharma et al., 2020). However, an increase in imports beyond a threshold comes with a cost, which is an aggravating trade deficit. For instance, India's dependence on China for the import of active pharmaceutical ingredients (APIs) generally remains high (Ahmed et al., 2020; Cherian et al., 2021), though the production linked incentive (PLI) scheme has lowered the same for a few commodity groups (Joseph & Kumar, 2021).[2]

The import dependence on the APIs segment persists in spite of the GOI introducing a series of fiscal, financial and tariff reforms, since the launch of the 'Make-in-India' scheme in 2014 to enhance the competitiveness of the pharma sector (Chakraborty & Banik, 2020). For example, in the Foreign Trade Policy (2015–2020), pharma and biotechnology sectors were included under the 'focus market scheme', with the GOI providing incentives on exports that can be used later to settle against the future import duties on raw material to be used for pharmaceutical exports.[3] In the case of medical devices, to facilitate technology transfer from developed countries, foreign direct investment was freely allowed in the pharmaceutical sector (up to 100%) through the automatic route. This set of reforms has led to mixed results so far. In some sectors, for example, the high-value-added pharmaceutical exports such as formulation and vaccines, India is performing well.[4] The share of domestic value-added content in foreign final demand went up by 6.2%, from 32.6% in 2005 to 38.8% in 2016, underlining lower import dependence in these categories (Export Import Bank of India, 2016). However, India continues to sustain higher trade deficits in certain segments of API, personal protective equipment, disinfectant and medical equipment segments, indicating a differential impact of reforms.

The second method to deal with the shortage of medicines and medical equipment, and to enhance their easy availability is to put in place an efficient pharmaceutical supply chain (PSC). Lakner et al. (2019), argues that distribution, inventory management and customer service across the pharmaceutical value chains are important to increase accessibility and reduce the price of pharmaceutical products. The PSC in India faces a variety of challenges and is characterised by product fragmentation, poor

infrastructure and low-quality products (Kearney Insight, 2016). The demand and supply mismatch of final and intermediate medicinal products have an impact on firm-level operational performance, measured by operating income, sales, total cost and inventory (Hendricks & Singhal, 2005). It has often been noted that there is ample scope for improving India's supply chain resilience through innovation in process and shipment management and switching to more technology-intensive operations (e.g., automation in the assembly line) during production (Bolineni, 2016). The supply chain challenges witnessed during the pandemic period require Indian pharma companies to embrace several modifications, including but not necessarily limited to areas, such as operations management, screening protocol, inventory policy, in-and-outbound logistics, demand-supply synchronisation and global scenario planning (Sharma et al., 2020). The risk associated with exposure to API imports from China in the post-COVID-19 period forced the Indian government to offer, 'guaranteed purchase agreements for existing domestic API manufacturing factories calculated on the demand of Indian pharmaceutical firms' (Jha & Sharma, 2020). While the support provided a short-term respite, there is a need for identifying the constraints on domestic players to enhance supply chain resilience. An efficient PSC by increasing productivity at a firm level may not only help to facilitate supply potential but also can improve India's trade balance. Moreover, the assured supply of APIs from domestic players, through targeted capacity creation, can reduce production uncertainties on one hand and increase the suitability of Indian firms as ideal partners for contract manufacturing by global majors on the other.

Given this premise, the article is organised as follows. Section II identifies the research gap in the Indian context. Section III deals with the analytical framework and the data. Results on India's comparative advantage in medicines, vaccines and other COVID-19-related medical products are presented in Section IV. The competitiveness results are further linked with India's trade policy framework, namely tariffs and NTMs. Section V focuses on the supply chain management issues of vaccines, medicines and other medical items through a primary analysis involving key Indian stakeholders. Finally, based on the observations, Section 6 concludes.

Research Gap and Objective

Over the years India has emerged as a major exporter of pharmaceutical products, particularly generic medicines (Export Import Bank of India, 2016). The Indian pharmaceutical industry is the second largest in the world accounting for 70% of the bulk, intermediate and formulation drugs (Panda, 2017). And yet, the second wave of the COVID-19 crisis has shown that India is not self-sufficient in manufacturing certain types of APIs, and other COVID-19-related medical items. To tide over the scarcity of these essential medicines, vaccines and related medical items, India had to depend on imports in the short run. Trade in COVID-19 medicines, vaccines and other related medical items is critically influenced by tariffs and NTMs. Import tariffs are the chief trade barrier responsible for inflating end prices, as such border surcharges are amplified and compounded as a product moves down the distribution chain (Bauer, 2017). Though the tariff on pharma products has come down in India after joining WTO, it remains relatively higher across some product groups (Kallummal & Bugalya, 2012). It is noted that customs duties explain approximately, '11% of the end-user price for international manufacturers' products but do not impact products sourced from the domestic production of APIs and finished form products' (Aitken, 2016). Likewise, NTMs which are defined as policy measures other than custom tariffs can potentially have an economic effect on international trade in goods.

The analysis contributes to the existing literature in two ways. First, we examine whether a lower comparative advantage might constitute a reason behind India's orientation to follow an inward-looking trade strategy, by considering the corresponding tariffs and NTMs data. A similar analysis with important product groups has not been conducted in recent times. Second, to understand how the perceived domestic distortions emanating from logistic, operational and financial issues impacted the availability of medicines and vaccines, we undertook an exploratory qualitative (factor analysis) approach. This aspect of examining the resilience of India's PSC, through analysis of the financial, logistic and operational issues to understand which one of these factors potentially disrupted the supply chain in the aftermath of the second wave of COVID-19 is relatively scarce in the existing literature.

Comparative Advantage for India's Pharmaceutical Products

Analytical Framework

Let us denote India as country *i*, the world as *w*, any specific sector as *k* (and *K* the total number of sectors), and *t* as the time period for which this analysis is done. Furthermore, we denote India's exports as *X* and imports as M. Given these notations, the revealed comparative advantage (RCA) index for India as per Balassa Index (1965) is given by

$$RCA = \frac{\frac{X_{ik}}{X_i}}{\frac{X_{wk}}{X_w}} = \frac{\frac{X_{ik}}{X_{wk}}}{\sum_{k=1}^{K} \frac{X_{ik}}{X_{wk}} \cdot \frac{X_{wk}}{X_w}} \equiv \frac{\frac{X_{ik}}{X_{wk}}}{\frac{X_i}{X_w}}$$

RCA for India is a relative export measure for a particular sector *k* in terms of share of world exports. It can also be interpreted as the country's share of sectoral export, that is, $\frac{X_{ik}}{X_{wk}}$, normalised by a weighted sum of exports shares in all sectors which is equivalent to $\frac{X_i}{X_w}$. It is to be noted that the numerator ranges from zero (which means India does not export this particular commodity) to 1 (the case of international monopoly with India as the only producer). The denominator, depending upon the economic dimension of the country, also varies between zero and 1. Therefore, *RCA* ranges between zero and ∞, and is equal to 1 when $\frac{X_{ik}}{X_{wk}} = \frac{X_i}{X_w}$. Hence, India does not have a comparative advantage in sector *k* if 0 < RCA < 1, whereas it displays a comparative advantage in sector *k,* if $1 < RCA < \infty$.

In addition to RCA, using the import data, we compute the revealed comparative disadvantage (RCDA) index in a symmetric manner:

$$RCDA = \frac{\frac{M_{ik}}{M_i}}{\frac{M_{wk}}{M_w}}$$

India does not have a comparative disadvantage in sector k if $0 < \text{RCDA} < 1$, whereas it suffers from a comparative disadvantage in sector k, if $1 < RCA < \infty$

The RCA–RCDA index results can be interpreted jointly in the following manner. If for a particular product, the RCA is greater than 1 and RCDA is less than 1, a country can be called an ideal exporter of that product. Similarly, if RCA is less than 1 and RCDA is greater than 1, then the country will be better off importing that item. If both RCA and RCDA are greater than 1, then a simultaneous export and import is taking place in the country, signifying the presence of intra-industry trade (IIT) for that item. However, if both the RCA and RCDA are lesser than 1, then the country is likely to be self-sufficient in this commodity, as reflected by the low trade penetration vis-à-vis the world.

Data

For the analysis, we consider 41 different COVID-19 medical products spreading across six broad categories, namely APIs (10 products), vaccines and formulations (five products), medical and non-medical wearables (12 products), disinfectants and sterilisation products (five products), and medical devices and equipment (nine products). Trade data are based on harmonised system (HS) Codes (at a 6-digit level of HS Classification), which are obtained from International Trade Centre (n.d.-a). The 41 HS 6-digit products have been selected in the following manner. It has been observed that these products have faced export restrictions imposed by the government during 2020–2021, as observed from Public Notices issued by the Directorate General of Foreign Trade (GOI, n.d.). The underlying logic is that GOI has imposed export restrictions only when enhancing their availability in the domestic market has been important for: (a) manufacturing a COVID-19 medicine, (b) directly treating a COVID-19 patient for curative purposes, (c) for supportive care in the post-COVID-19 period or (d) ensuring physical safety protocol. To obtain an insight into India's competitiveness across the value chain, the analysis has deliberately selected products at various stages of processing, for example, API for Vitamin B1 (classified within HS 293622) and formulations of Vitamin B1 (classified within HS 300450), rather than focussing on a particular COVID-19-related product segment (e.g., vaccines). A detailed description of the products examined is reported in Table A1.[5]

For identifying the NTMs imposed on each of the selected 41 HS 6-digit products, we use Market Access Map (MACMAP) database provided by the International Trade Centre (ITC). This retrieved data reflects the total number of NTMs on each HS 6-digit product code which are in force during the year 2021. Tariffs data on the selected products are sourced from World Integrated Trade Solution (WITS) database, World Bank; and Ministry of Commerce, GOI. The trade data is drawn over 2001–2020, as obtained from the Trade Map database provided by the ITC. For observing the temporal perspective, the analysis is undertaken and compared over four sequential sub-periods, namely 2001–2005, 2006–2010, 2011–2015 and 2016–2020, respectively. During the first period (2001–2005), India adopted a cautious attitude by gradually embracing the product patent regime (from 1 January 2005, onwards). The second period (2006–2010) was marked by India signing various regional trade agreements (RTAs).[6] Some of the ongoing RTA negotiations were concluded during the initial years of the third phase.[7] Thereafter, during the last two phases (2011–2015 and 2016–2020), Indian policymakers concentrated on manufacturing sector consolidation, initially with the 'Make-in-India' scheme (2014), followed by the launch of the 'Atmanirbhar Bharat Abhiyan' (self-reliance) in 2020.

Table 1. Competitiveness of India in Select Product Categories.

		RCA				RCDA			
Sl No.	HS Code	2001–2005	2006–2010	2011–2015	2016–2020	2001–2005	2006–2010	2011–2015	2016–2020
Active Pharmaceutical Ingredients (APIs)									
1	293339	0.25	0.74	1.42	2.86	0.38	0.47	0.55	0.81
2	293349	0.40	0.38	2.58	6.52	0.08	0.14	0.57	1.15
3	293359	0.22	0.61	0.64	1.12	0.21	0.48	0.43	0.58
4	293399	0.06	0.16	1.28	3.03	0.04	0.12	0.33	1.44
5	293622	0.38	1.23	1.35	1.77	1.48	1.73	1.53	2.12
6	293625	0.07	0.01	0.04	0.08	1.44	1.08	1.34	1.41
7	293626	7.25	2.41	0.52	0.67	1.52	3.76	3.80	4.98
8	293627	0.03	0.03	0.17	0.29	0.41	0.31	0.29	0.54
9	294190	2.30	2.60	4.09	4.45	1.24	1.82	1.87	3.01
10	294200	84.57	64.50	43.68	39.02	45.03	24.06	20.53	13.97
Vaccines and Formulations									
1	300220	2.01	1.11	1.21	1.55	0.88	0.34	0.41	0.46
2	300420	2.48	3.84	3.51	4.25	0.06	0.05	0.09	0.11
3	300439	0.28	0.21	0.25	0.20	0.11	0.10	0.11	0.09
4	300450	3.89	4.32	3.24	3.41	0.09	0.09	0.05	0.06
5	300490	0.88	0.92	1.74	2.44	0.09	0.11	0.08	0.10
Wearables (Raw Materials)									
1	560311	0.03	0.12	0.23	0.44	0.40	0.21	0.52	0.88
2	560312	0.01	0.44	0.93	1.18	0.21	0.18	0.18	0.23
3	560314	0.04	0.03	0.16	0.46	0.11	0.19	0.41	0.54
4	560391	0.03	0.02	0.11	0.07	1.13	0.29	0.55	0.71
5	560392	0.00	0.02	0.05	0.05	0.47	0.21	0.40	0.87
6	560393	0.01	0.01	0.07	0.17	0.57	0.26	0.27	0.43
7	560394	0.03	0.04	0.11	0.13	1.22	0.98	1.19	1.29
Medical and Non-medical Wearables (Final Products)									
1	392690	0.39	0.50	0.54	0.56	0.41	0.45	0.50	0.55
2	401511	2.72	1.76	1.42	1.40	0.05	0.15	0.38	0.45

(Table 1 continued)

(Table 1 continued)

Sl No.	HS Code	RCA				RCDA			
		2001–2005	2006–2010	2011–2015	2016–2020	2001–2005	2006–2010	2011–2015	2016–2020
3	621790	0.24	0.72	0.70	0.56	0.10	0.14	0.10	0.15
4	630790	13.50	4.01	2.13	2.15	0.17	0.13	0.08	0.11
Disinfectants and Sterilisation Products									
1	300215	–	–	–	0.04	–	–	–	0.05
2	380894	–	–	0.44	0.41	–	–	0.08	0.10
3	701010	1.84	2.29	2.31	3.00	0.39	0.47	0.62	1.52
4	701090	0.66	0.95	1.12	1.25	0.06	0.18	0.21	0.24
5	841990	0.79	1.11	0.87	0.90	1.15	1.24	0.91	0.85
Medical Devices and Equipment									
1	841920	0.13	0.47	0.51	0.43	1.06	1.10	1.16	1.55
2	901811	0.68	0.41	0.51	1.53	0.24	0.25	0.23	0.33
3	901812	2.00	0.45	0.64	0.39	1.49	1.00	0.83	1.19
4	901819	0.30	0.55	0.43	0.40	1.89	0.83	0.49	0.24
5	901839	0.26	0.30	0.43	0.54	0.59	0.47	0.36	0.36
6	901850	0.17	0.26	0.23	0.32	2.62	1.48	1.57	1.41
7	901890	0.26	0.27	0.24	0.26	0.83	0.60	0.46	0.50
8	901920	0.03	0.04	0.03	0.05	0.53	0.34	0.43	0.67
9	902000	0.05	0.04	0.16	0.07	0.37	0.34	0.33	0.33
10	902212	0.13	0.02	0.03	0.15	1.11	1.01	1.01	1.10

Source: Computed by authors using trade data sourced from Trade Map (https://www.trademap.org/).

Results and Analysis

Tables 1, 2 and 3 bring out some interesting observations. As seen from Table 1, in general, India enjoys a comparative advantage in manufacturing vaccines and formulations, and a few API segments. On the contrary, the country lacks a clear comparative advantage in manufacturing other COVID-19-related medical items, such as medical and non-medical wearables, medical instruments, disinfectants and sterilisation products. The higher RCA value (reflecting comparative advantage) also translates into a favourable trade balance across several sectors, which is summarised in Table 2.

In the API segment, the RCA values increased over time for several product groups, indicating that India is also consolidating its position as an exporter in this product category. Considering the items HS-293339 and HS-293349 (Hydroxychloroquine), initially, the RCA values were lesser than unity, but

Table 2. India's Trade Balance Scenario in Select Product Categories (USD Million).

Sl No.	HS Code	2001–2005	2006–2010	2011–2015	2016–2020	February 21
Active Pharmaceutical Ingredients (APIs)						
1	293339	−17.03	0.29	99.53	317.69	43.07
2	293349	2.78	8.46	65.50	91.01	3.02
3	293359	−2.69	−34.57	−22.20	63.65	13.26
4	293399	−1.86	−13.40	153.73	174.04	8.80
5	293622	−1.85	−3.22	−3.54	−9.83	−0.97
6	293625	−1.75	−3.07	−6.68	−9.70	−0.62
7	293626	4.82	−7.28	−19.24	−39.86	−4.40
8	293627	−2.64	−7.76	−4.12	−10.06	−1.78
9	294190	25.08	−32.25	117.76	−62.14	−20.77
10	294200	604.27	1476.97	862.44	677.64	65.53
Vaccines and Formulations						
1	300220	32.12	77.59	256.66	386.05	88.66
2	300420	167.42	555.03	856.62	999.77	77.08
3	300439	8.83	6.33	18.57	13.50	5.91
4	300450	78.20	207.96	251.29	240.29	22.75
5	300490	765.51	2165.91	7061.50	10593.11	1,142.12
Wearables (Raw Materials)						
1	560311	−4.38	−3.47	−20.97	−33.84	−2.31
2	560312	−3.01	5.48	31.31	49.35	10.38
3	560314	−0.61	−4.46	−13.15	−8.45	−1.53
4	560391	−2.01	−1.79	−3.47	−5.79	−0.46
5	560392	−3.89	−3.85	−14.37	−42.25	−4.85
6	560393	−1.86	−2.53	−4.54	−6.61	−0.88
7	560394	−7.26	−17.20	−36.54	−46.47	−3.55
Medical and Non-medical Wearables (Final Products)						
1	392690	−30.15	−104.89	−178.47	−242.21	−25.71
2	401511	11.17	13.29	12.43	12.45	3.53
3	621790	1.08	4.65	9.00	5.85	0.27
4	630790	403.25	246.10	304.24	395.46	32.42

(Table 2 continued)

(Table 2 continued)

Sl No.	HS Code	2001–2005	2006–2010	2011–2015	2016–2020	February 21
Disinfectants and Sterilisation Products						
1	300215	0.00	0.00	0.00	−22.96	3.83
2	380894	0.00	1.57	8.65	14.22	2.52
3	701010	1.43	2.31	3.27	1.45	−0.25
4	701090	22.40	58.50	121.60	157.86	16.98
5	841990	−12.74	−46.98	−45.21	−37.17	−8.43
Medical Devices and Equipment						
1	841920	−4.13	−11.88	−21.69	−31.26	−2.23
2	901811	2.81	1.12	2.35	18.94	3.25
3	901812	−2.18	−48.84	−49.68	−112.05	−7.94
4	901819	−64.60	−51.32	−37.05	16.44	1.03
5	901839	−26.54	−77.53	−10.90	34.34	10.71
6	901850	−35.38	−64.30	−133.99	−127.30	−9.59
7	901890	−127.54	−263.93	−347.07	−429.81	−31.1
8	901920	−7.86	−26.01	−63.43	−143.38	−9.15
9	902000	−2.00	−5.85	−6.99	−12.59	−0.67
10	902212	−18.59	−54.09	−82.78	−86.69	−8.95

Source: Computed by authors from Trade Map (https://www.trademap.org/) and Ministry of Commerce, GOI (https://commerce.gov.in/trade-statistics/export-import-data-bank-monthly/) data.

Table 3. Custom Tariff Rates (%)

		Weighted Average Tariff				Free Import as % of Total Import			
Sl No.	HS Code	2001–2005	2006–2010	2011–2015	2016–2019	2001–2005	2006–2010	2011–2015	2016–2019
Active Pharmaceutical Ingredients (APIs)									
1	293339	27.00	9.60	7.50	7.32	0.00	0.00	0.00	0.54
2	293349	25.00	9.59	7.50	7.45	0.00	0.00	0.00	0.37
3	293359	27.00	9.58	7.50	7.39	0.00	0.00	0.00	0.51
4	293399	25.00	9.11	7.50	6.56	0.00	0.00	0.00	0.26
5	293622	27.00	9.58	7.50	6.76	0.00	0.00	0.00	13.26
6	293625	27.00	9.60	7.50	6.85	0.00	0.00	0.00	10.85

(Table 3 continued)

(Table 3 continued)

		Weighted Average Tariff				Free Import as % of Total Import			
Sl No.	HS Code	2001–2005	2006–2010	2011–2015	2016–2019	2001–2005	2006–2010	2011–2015	2016–2019
7	293626	27.00	9.59	7.50	7.44	0.00	0.03	0.00	0.15
8	293627	27.00	9.57	7.50	6.53	0.00	0.09	0.00	11.83
9	294190	26.65	9.54	7.50	7.36	2.64	0.00	0.00	1.71
10	294200	26.99	9.53	7.50	7.35	0.08	0.00	0.00	0.88
Vaccines and Formulations									
1	300220	27.00	10.67	10.00	7.35	0.00	0.00	0.00	26.48
2	300420	26.66	10.99	10.00	10.00	0.01	0.00	0.00	0.00
3	300439	27.00	10.96	10.00	9.59	0.00	0.00	0.00	3.53
4	300450	27.00	10.59	10.00	8.82	0.00	0.00	0.00	11.11
5	300490	26.92	10.96	10.00	9.64	0.17	0.18	0.00	0.63
Wearables (Raw Materials)									
1	560311	23.00	10.06	9.99	5.55	0.00	2.77	0.08	48.22
2	560312	22.99	10.64	10.00	11.14	0.00	2.48	0.00	8.39
3	560314	22.99	10.65	10.00	10.22	0.00	0.00	0.00	14.80
4	560391	23.00	10.82	10.00	4.06	0.00	0.00	0.00	47.92
5	560392	23.00	10.88	9.99	8.36	0.00	1.01	0.08	34.06
6	560393	23.00	10.75	9.93	8.78	0.00	0.00	0.73	11.02
7	560394	23.00	10.62	10.00	8.38	0.00	2.77	0.00	29.38
Medical and Non-medical Wearables (Final Products)									
1	392690	26.78	10.32	9.93	9.10	0.00	5.59	0.00	10.87
2	401511	22.39	8.60	10.00	0.24	12.65	15.56	0.00	97.52
3	621790	26.92	10.25	9.82	9.66	0.00	7.15	1.84	24.64
4	630790	26.98	10.75	9.99	8.88	0.00	0.00	0.08	10.64
Disinfectants and Sterilisation Products									
1	300215	–	–	–	9.97	–	–	–	0.03
2	380894	–	10.62	10.00	9.76	0.00	0.00	0.00	0.01
3	701010	27.00	10.88	10.00	9.97	0.00	0.00	0.00	0.21
4	701090	22.47	8.64	9.48	7.62	0.20	17.26	4.68	17.98
5	841990	23.00	7.74	7.90	7.66	0.00	2.18	0.00	9.00

(Table 3 continued)

(Table 3 continued)

Sl No.	HS Code	Weighted Average Tariff				Free Import as % of Total Import			
		2001–2005	2006–2010	2011–2015	2016–2019	2001–2005	2006–2010	2011–2015	2016–2019
Medical Devices and Equipment									
1	841920	23.00	9.50	7.50	6.75	0.00	0.00	0.01	7.82
2	901811	22.80	9.55	7.50	7.11	1.32	0.00	0.00	5.08
3	901812	22.99	9.23	7.50	4.98	0.06	0.14	0.00	25.03
4	901819	23.00	9.06	7.50	6.55	0.02	1.63	0.00	7.49
5	901839	23.00	9.25	7.50	5.82	0.00	1.40	0.00	16.29
6	901850	23.00	9.45	7.50	6.22	0.00	0.74	0.00	2.64
7	901890	22.99	9.34	7.50	6.08	0.03	0.01	0.00	8.42
8	901920	23.00	9.32	7.50	7.16	0.00	2.89	0.00	3.93
9	902000	23.00	8.99	7.50	6.19	0.00	4.58	0.00	13.51
10	902212	23.00	9.39	7.50	6.01	0.00	0.00	0.00	5.35

Source: Computed by authors from WITS (https://wits.worldbank.org/).

crossed the competitiveness threshold value over time. For the API items with an RCA value greater than unity, India enjoys a trade surplus. However, for the API items with an RCA value less than unity, India suffers from a trade deficit, e.g.: HS-293622 (vitamin B1), HS-293625 (vitamin B6), HS-293626 (vitamin B12), and HS-293627 (vitamin C), implying an absence of comparative advantage. The notable exception is HS-294190 (Neomycin, Rifampicin, and Clindamycin salts), where India suffers from a trade deficit. In this category, both the RCA and RCDA values are greater than unity, implying the existence of IIT.

In the vaccines and formulations segment, India clearly enjoys a comparative advantage. For all the items within this category, except for HS-300439 (formulations made of progesterone, oestrogen, etc.), RCA and RCDA values are greater than and less than unity, respectively, underlining India's comparative advantage in this segment. In particular, for HS-300220 (all vaccines for human medicine, including COVID-19 vaccines), India enjoys a strong comparative advantage in the manufacturing of these products, which are witnessing growing demand in the global market.

For most of the items falling under wearables (raw materials), medical and non-medical wearables (final products), disinfectants and sterilisation products, and medical devices and equipment sub-categories, India does not possess a comparative advantage. During 2016–2020, only HS-560312 (non-woven fabrics of 25–70 grams per square metre (GSM)), HS-401511 (surgical rubber or medical examination rubber gloves), HS-701010 (glass containers for vaccines), HS-901819 (pulse oximeters) and HS-901811 (electrocardiograph), RCA value has been greater than unity. For all other items, RCA values were lesser than unity, indicating an absence of comparative advantage. With the surge in COVID-19 cases during the second wave in 2021, India had to start importing these items, and several categories incurred a trade deficit.

Considering the machinery segment, we observe that India always witnessed lower RCA and RCDA values for several medical items critical for treating COVID-19 patients such as HS-901920 (ventilators, oxygen humidifiers, CPAP, BIPAP, oxygen concentrators, etc.) and HS-902000 (other breathing appliances and gas masks, excluding protective masks having neither mechanical parts).

Overall, Tables 1 and 2 reveal that products with higher RCA values tend to indicate comparative advantage and ideally reflect trade surplus in favour of India. While the RCA-RCDA results jointly underline India's competitiveness patterns, the trade balance scenario is an indicator of evolving specialisation. For example, in the vaccines and formulations category, India runs a trade surplus. Similar is the case with a few wearable items (raw materials), medical and non-medical wearables (final products), disinfectants and sterilisation products and medical devices and equipment—items with higher RCA scores translating into a favourable trade balance for the country. However, during the pandemic period, import dependence of the country on China has increased for several product groups (Banik et al., 2021).

Interestingly, irrespective of the RCA and RCDA results, India has followed a defensive trade regime, marked by the presence of higher trade-weighted average tariff rates across APIs, vaccines, formulations, and other COVID-19-related product categories as shown in Table 3. Although India has reduced pharmaceutical tariffs, from the high level of 25%–27% during 2001–2005 to the present level of 7%–10% during 2016–2019, it remained one of the most strongly protected markets in the world. For the vaccines and formulation segment, India has a high tariff average of 10%, vis-à-vis the tariffs of 5% or lower, among many developed countries. Over 2001–18, the average global tariffs on medicines have fallen from 4.9% to 3.2%. While India witnessed a sharp decline in average tariffs on pharmaceutical products in percentage terms since 2001; several middle-to-high-income countries like Nigeria, Ghana, Chile, Mongolia, Israel and Bahrain have eliminated tariffs over the period (Stevens & Banik, 2020). It is observed that while India's average tariff on pharmaceutical products has declined from 12.32% to 9.87% from 2006–2020, the corresponding figures for China had been 4.81 and 1.85% in that order. In addition, although average tariffs have fallen, a number of dutiable tariff lines fluctuated over this period.

From Table 3, it is further observed that for all the product categories, namely formulations and vaccines, wearables, medical and non-medical wearables, test kits etc., disinfectants and sterilisation products and medical devices, India has gradually reduced the tariff rate on imports. The only exception has been non-woven fabrics of 25–70 GSM (HS 560312), where the tariff rate has increased in the recent period. While the result indicates a general transition towards a reformist approach, it is also evident that the average tariff reduction from 2011–2015 to 2016–2019 has been quite modest.

Moreover, the Indian market is characterised by several NTMs on imports of the selected pharmaceutical products, which are summarised category-wise in Figure 1, by drawing data from MACMAP, ITC. Imposition of TBT provisions and regulations on packaging and labelling are quite common on the selected COVID-19-related products. As the compliance requirements may lead to cost escalation for the imported products, there is considerable scope for entering into mutual recognition agreements (MRAs) involving pharma products with key trade partners for lowering the domestic price of these products, and thereby improving public health outcomes.

The defensive policy intervention in India towards pharma products can be linked to the fact that for many APIs and other products, the country is dependent on imports from China and enhancing their production is crucial under the current policy framework (Ahmed et al., 2020). During 2020, Chinese bulk-drug imports to India stood at $2.6 billion which is estimated to grow at an annualised rate of 5% over the next four years. The higher tariff barrier across the value stream would in effect protect and nurture the domestic pharmaceutical sector.[8] Although tariffs on the API segment (HS-29) continued to remain high (as compared to the corresponding tariff rate of 5.64% in China during 2020), a sharp

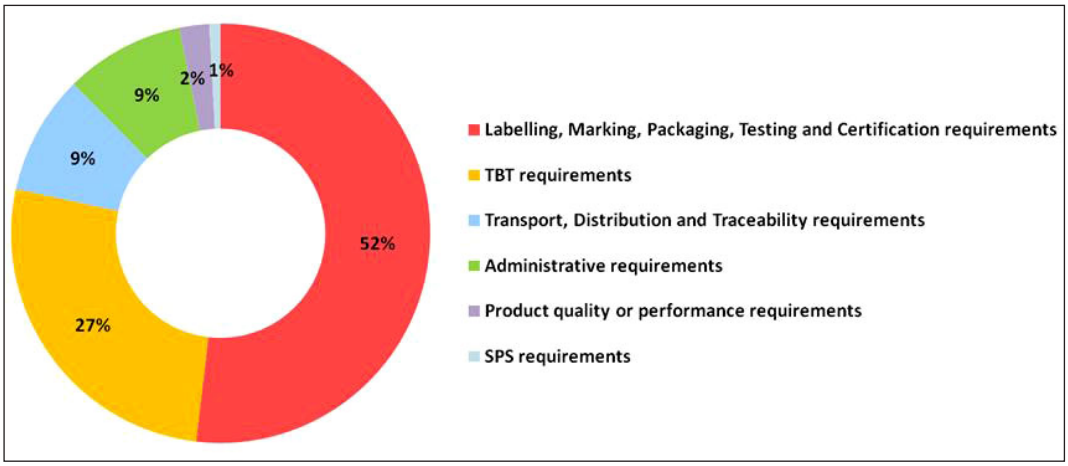

Figure 1. Distribution of NTMs Imposed by India on Selected Products During 2020.

Source: Constructed by Authors from International Trade Centre (n.d.-b).

reduction since 2005 helped the Indian vaccines and formulations manufacturers procure intermediate inputs at a relatively cheaper price. This helped the country to consolidate its position in the vaccines and formulations segment significantly. For instance, India's export in the vaccines and formulations segment (HS-30) increased from $2.45 billion to $16.64 billion between 2006 and 2020. As seen from Table 2, while in several API sub-sectors, India suffered from a trade deficit, the trade surplus in vaccines and formulations has generally increased. In 2020, the trade surplus for India in the APIs and formulations segments collectively stood at $1.40 and $14.80 million, respectively. It can be concluded that the government initiatives to intervene and enhance the competitiveness of the pharmaceuticals sector has delivered a mixed result so far.

Supply Chain Management in Case of COVID-19 Vaccines and Medicines

An exploratory qualitative approach has been adopted to examine the efficiency of the COVID-19-related vaccine and medicine supply chain in India and the possible reasons behind the shortage witnessed in April–May 2021. The data for the analysis have been gathered through a primary survey, by designing a structured questionnaire. Respondents for the current analysis comprised medical doctors and corporate executives working for pharmaceutical companies. The medical doctors approached for the analysis are associated with primary healthcare centres (PHC), dispensaries, community healthcare centres (CHC), and central government health scheme (CGHS) wellness centres and include private practitioners as well. The questionnaire consists of a 5-point Likert scale ranging from 'never/no' to 'always/yes' option. The questionnaire was divided into three broad sub-headings – logistics issues, financial issues, and operational issues – related to the availability of vaccines and medicines.[9] As a precautionary measure, we explained all the terms mentioned in the questionnaire. Rather than giving the option 'do not know' we used 'occasionally'. The questionnaire consisted of 17 fields covering logistics, financial and operational issues. The list of issues covered in the questionnaire is reported in Table A2.

For obtaining a detailed perspective on the three areas considered in the current analysis, both doctors involved in the direct treatment of patients with COVID-19 and corporate executives involved with strategic decision-making were interviewed. The sample frame for the survey has been selected in the following manner. Given India's supply chain exposure to China on API and other product import dependencies, all the pharmaceutical companies selected in the survey either import API from China and use them for manufacturing medicines and vaccines or import medicinal equipment from China. Some firms are also dependent on imports from the USA for certain critical inputs used for vaccine manufacturing. We identified mid-to-top-level corporate executives from 100 pharmaceutical companies with the aforesaid specifications as potential respondents.[10] For medical doctors we use the database of PHC, private dispensaries, CHC and CGHS wellness centres, totalling 300. The medical doctors and pharmaceutical corporate executives in the sample were selected from the National Capital Region (NCR) of Delhi. We used a stratified sampling method with selection based on simple random sampling without replacement. The survey was conducted between 3 April 2021 and 29 August 2021, a period when the second COVID-19 wave was felt in the country in general and in the NCR region in particular. We segregated the questionnaire depending on the profession. While the questions related to logistic issues were asked of medical doctors, the ones related to operational and financial issues were asked of the pharmaceutical corporate executives. The final sample size for the analysis comprises 30 medical doctors and 30 corporate executives from pharmaceutical companies.

Table 4. Summary of Descriptive Statistics.

	Never/ No (%)	Always/ Yes (%)	Occasionally (%)
Operational Issues			
Ability to scale up vaccine production for instance acquiring specialised capital equipment such as bioreactors and filtration pumps, and access to critical inputs such as lipid nanoparticles and skilled labourers.	54	42	4
Ability to scale up specialised assembly-line capital equipment and variable inputs such as glass vials and stoppers.	36	56	8
Cooperation and collaboration among multiple stakeholders including public health officials, government agencies, pharmaceutical manufacturers and distributors among others.	31	58	11
Government regulations delay permission for domestic pharma companies to start contract vaccine manufacturing in India.	69	10	21
Vaccine hesitancy results from a lack of awareness and understanding of the vaccines.	20	76	4
Financial Issues			
Higher shipment cost for APIs resulting from shipping container shortage during the second wave of COVID-19.	12	82	6
Steep rise in prices of Chinese APIs at the time of heightened demand during the second wave of COVID-19.	10	88	2

(Table 4 continued)

(Table 4 continued)

	Never/ No (%)	Always/ Yes (%)	Occasionally (%)
The US embargo on exporting COVID-19 vaccine raw materials during the second wave of COVID-19.	56	32	8
Higher tariffs cost escalating the price of medicines, vaccines, and medical equipment.	85	13	2
Higher costs associated with compliance with procedures and NTMs, escalating the price of medicines and vaccines.	39	45	16
Infrastructural issues such as congested and poor road conditions lead to cost escalation.	22	74	4
Logistic Issues			
Availability of cold storage facilities for vaccines in PHC, CHC and CGHS.	10	89	1
Availability of RT PCR testing facilities in PHC, CHC and CGHS.	69	21	10
Availability of needles, syringes, antiseptic wipes, and other pharmaceutical ingredients needed for administering vaccines.	22	74	4
Maintaining temperature control while storing vaccines.	2	88	10
Maintaining temperature control while transporting vaccines.	59	3	38
A digital presence in rural India to spread awareness about COVID-19 vaccination.	62	30	8

Table 5. Results and Reliability of Scales.

	Factor Loading	Total variance explained	Measure of Sample Adequacy	Reliability (Cronbach's Alpha)
Operational Issues		49.34	0.72	0.76
Ability to scale up vaccine production for instance acquiring specialized capital equipment such as bioreactors and filtration pumps, and access to critical inputs such as lipid nanoparticles and skilled labourers.	0.79			
Ability to scale up specialized assembly-line capital equipment and variable inputs such as glass vials and stoppers.	0.71			
Cooperation and collaboration among multiple stake holders including public health officials, government agencies, pharmaceutical manufactures, and distributors among others.	0.88			

(Table 5 continued)

(Table 5 continued)

	Factor Loading	Total variance explained	Measure of Sample Adequacy	Reliability (Cronbach's Alpha)
Operational Issues		49.34	0.72	0.76
Vaccine hesitancy resulting from lack of awareness and understanding of the vaccines.	0.84			
Government regulations delaying permission to domestic pharma companies to start contract vaccine manufacturing in India.	0.83			
Financial Issues		60.12	0.87	0.73
Higher shipment cost for APIs resulting from shipping container shortage during second wave of COVID-19.	0.77			
Steep rise in prices of Chinese APIs at the time of heightened demand during second wave of COVID-19.	0.68			
The US embargo on exporting COVID vaccine raw materials during second wave of COVID-19.	0.52			
Higher tariffs cost escalating the price of medicines, vaccines, and medical equipment.	0.64			
Higher costs associated with compliance of procedures and NTMs, escalating the price of medicines and vaccines.	0.82			
Infrastructural issues such as congested and poor road conditions leading to cost escalation.	0.69			
Logistic Issues		68.23	0.81	0.82
Availability of cold storage facilities for vaccines in PHC, CHC, and CGHS.	0.80			
Availability of RT PCR testing facilities in PHC, CHC, and CGHS.	0.83			
Availability of needles, syringes, antiseptic wipes, and other pharmaceutical ingredients needed for administering vaccines.	0.92			
Maintaining temperature control while storing vaccines.	0.64			
Maintaining temperature control while transporting vaccines.	0.71			
Digital presence in rural India to spread awareness about COVID-19 vaccination.	0.66			

Source: Author's computation

We perform factor analysis on the obtained responses regarding each one of these three variables, that is, operational issues, financial issues, and logistic issues, separately. The weights are derived using principal component analysis (PCA). PCA was performed on each one of the three items and their constituent elements, separately. The results of the statistical analysis are reported in Tables 4 and 5. The Kaiser–Meyer–Olkin indices for measuring sampling adequacy are 0.72 for operational issues, 0.87 for financial issues and 0.81 for logistic issues, indicating that the sampling is adequate. We observe that operational, financial and logistic issues contribute to explaining 49.34%, 60.12% and 68.23% of the total variance, respectively. No item was dropped during the process of factor analysis. Cronbach α values are 0.76, 0.73, and 0.82 for operational, financial and logistic issues, respectively, with each one of the components exceeding the standardised value of 0.7. We can therefore conclude that these three variables and their sub-components explain the reasons behind the vaccine supply shortage satisfactorily, as observed during the period of study.

The empirical results on supply chain challenges in India reveal that logistic issues are quite important. For instance, people were unwilling to take vaccines with fear emanating from a lack of trust, side effects and concern regarding the efficacy of the vaccines. The COVID-19 Symptom Survey conducted by Facebook in collaboration with the University of Maryland observed that in India there is a significant proportion of the population across states that are vaccine hesitant. The database covering 320 million Facebook users in India finds that Tamil Nadu top the list with 40% of its population hesitant to take vaccines. The corresponding numbers for other states are 33% for Punjab, 30% for Haryana, 29% for Gujarat, 29% for Andhra Pradesh, 19% for Odisha, Jharkhand and Kerala, 15% for Assam and 14% for Uttarakhand. Interestingly, 'religious belief' as a reason to opt out of vaccines was not found to be significant (Arora, 2021). In addition to these demand-side factors, there are also supply-side issues. For instance, reverse transcription polymerase chain reaction (RT-PCR) testing facilities are seldom available in PHCs, particularly in rural India. During the peak of the second COVID-19 wave during April, May and June 2021, there were inadequate RT-PCR testing centres in urban areas also. This led to patient inconvenience and delay in getting test results, resulting in hesitancy on the part of the people to get the testing done.

Among operational issues, lack of cooperation and collaboration among multiple stakeholders including public health officials, government agencies, pharmaceutical manufacturers and distributors among others gets a higher weight. Public health is a state subject in India. However, it is the GOI that is responsible for designing health policies and vaccine delivery mechanisms. There was a mismatch between the number of vaccines available for distribution and the demand for vaccines (Sood et al., 2021). India's pandemic response suffered because of a lack of policy clarity, transparency and accountability between the central government, state government and manufacturer of vaccines. Initially, there were problems associated with the online registration portal not working once the government opened up registration for vaccination to Indian citizens (above 18 years of age group) on 28 April 2021. Thereafter, there was difficulty in booking an online slot for vaccination, once the government portal started functioning starting early May 2021 (Bhattacharya, 2021). At a firm level, there was also a problem to scale-up production, particularly with respect to getting access to skilled labours and critical inputs needed for vaccine production.

Finally, among the financial issues, although tariffs resulted in an increase in the price of medicines and vaccines, it is the NTM measures that got higher weights, implying that they play a bigger role in supply chain disruption. Interestingly, the US embargo on exporting COVID-19 raw materials for vaccines has a lower weight. Trade data show that India's imports of COVID-19 raw materials from the USA increased between October 2020 and March 2021 (Bown & Rogers, 2021). The US President, Joe Biden, invoked the War Defence Production 1950 Act in January 2021, asking US pharmaceutical firms

to give priority to domestic production of COVID-19 vaccines. However, there is no comprehensive list of companies that were asked to focus on domestic consumption, nor there is a comprehensive list of all the raw materials that cannot be exported from the countries. Manufacturing vaccines require 9,000 different materials, and these can source from 300 suppliers spread across 30 countries (Raghavan, 2021). Therefore, we see in spite of the Defence Production Act being invoked, vaccines imported by India continued to rise. However, there was a higher price of vaccines resulting from supply chain disruption from China. The higher price of Chinese APIs was negatively impacting the supply. The extent of price-led disruptions becomes clear from the fact that Chinese suppliers of APIs and para-amino phenol (used for manufacturing paracetamol) increased prices by 20% and 27% in comparison to the pre-COVID-19 days (Sharma, 2020).

Conclusion

Given the comparative advantages in the medicine and formulations segment, aided by the cost advantages, India nurtures the aspiration to emerge as the vaccine hub of the world. The second wave of the COVID-19 crisis however underlined the supply-side challenges and domestic price uncertainties, caused by acute shortages at home. It is unlikely that India will receive the patent waivers on COVID-19-related medical products for the duration of the pandemic, that the developing countries have sought at the WTO. Hence the country needs to identify the major challenges and formulate a mitigation strategy accordingly.

A formidable challenge for India is its continued import dependence on several APIs and other medical equipment. For bringing down the domestic cost of these importable items, it is necessary to bring down tariffs and various NTMs (e.g., TBT provisions, including regulations on packaging and labelling). Despite a series of reforms, tariffs on APIs, vaccines, formulations, and other COVID-19-related medical items remain high vis-à-vis the global average, with the number of dutiable tariff lines in these categories increasing over the 2001–2019 period. Given that the majority of the patients in India have to pay out of their pockets for healthcare, these tariffs and NTMs might extract a higher proportion of income from the poor than those higher up the income scale. On the other hand, a reduction in tariffs, by lowering the price of intermediate inputs (APIs) can help the downstream pharma manufacturing sector emerge as a major competitor in the world market.

Additionally, to facilitate the easier availability of medicines, vaccines, and related items, there is a necessity to make PSC more efficient. The article identified several important operational, logistic, and financial issues and interventions which can make the PSC more efficient. Among the operational issues, there is a need for better coordination between multiple stakeholders in the supply chain and social advocacy to remove vaccine hesitancy and make people understand the importance of administering vaccines. For improving logistic issues there is a need for improving the general infrastructure. Like the consumers, Indian pharma manufacturing companies can benefit from financial issues such as a moderation in tariffs and NTMs, which are escalating the price of pharmaceutical inputs, and a reduction in shipment costs resulting from the shortage of containers at the time of pandemics. These are important lessons to be learned not only in the current context of COVID-19 but also in its long-term repercussions. Even with COVID-19 becoming endemic such as Ebola, Zika and Dengue, the post-recovery complexities for people with comorbidities (Demeco et al., 2020) and the potential occurrence of relapse indicates that global trade in this category would remain vibrant for some more time. There is a need to recognise this transformation in pharma-medical trade composition

and undertake trade policy-related and other systemic reforms to secure an efficient PSC. This will augment the competitiveness of the Indian pharmaceutical industry, in turn enabling them to expand their global presence in the long run.

Appendix A

Table A1. Description of the Products Used for the Analysis.

Active Pharmaceutical Ingredients (APIs)		
Sl No.	HS Code	Description
1	293339	Heterocyclic compounds with nitrogen hetero-atom[s] only, containing an unfused pyridine ring (Hydroxychloroquine)
2	293349	Heterocyclic compounds with nitrogen hetero-atom[s] only, containing in the structure a quinoline or isoquinoline ring system (Hydroxychloroquine)
3	293359	Heterocyclic compounds with nitrogen hetero-atom[s] only, containing a pyrimidine ring, whether or not hydrogenated (Acyclovir, Piperazine Anhydrous for Anthelmintic Drugs)
4	293399	Heterocyclic compounds with nitrogen hetero-atom[s] only (excluding those containing an unfused pyrazole (Hydroxychloroquine)
5	293622	Vitamin B1 and its derivatives
6	293625	Vitamin B6 and its derivatives
7	293626	Vitamin B12 and its derivatives
8	293627	Vitamin C and its derivatives
9	294190	Antibiotics (including Neomycin, Rifampicin and Clindamycin Salts)
10	294200	Separate chemically defined organic compounds, n.e.s. (Diloxanide furoate, Cimetidine, Oxyclozanide, Famotidine, Ornidazole, etc.)
Formulation and Vaccines		
Sl No.	HS Code	Description
1	300220	All vaccines for human medicine (including COVID-19 vaccines)
2	300420	Medicaments containing antibiotics (Formulations made of Chloramphenicol, Erythromycin and Clindamycin Salts)
3	300439	Medicaments containing hormones or steroids used as hormones but not antibiotics (Formulations made of Progesterone, Oestrogen, etc.)

(Appendix A continued)

(Appendix A continued)

4	300450	Medicaments containing provitamins and vitamins, incl. natural concentrates and derivatives thereof (formulations made of Vitamin B1, B6, B12, Others Amino Acid/Protein preparations with or without Vitamins, Spirulina, etc.)
5	300490	Medicaments consisting of mixed or unmixed products for therapeutic or prophylactic purposes (formulations made of Neomycin, Ornidazole, Metronidazole, Tinidazole, Acyclovir, Paracetamol, Amphotericin B, Amphotericin B (Liposomal), Hydroxychloroquine, Flourate/Furazolidone/Antibacterial, Anthelmintic, Tocilizumab, etc., Antibacterial formulations, not elsewhere specified or included)

Wearables (Raw Materials)

Sl No.	HS Code	Description
1	560311	Nonwovens, whether or not impregnated, coated, covered or laminated, n.e.s., of synthetic or man-made filaments, weighing <= 25 g/m² (non-woven fabrics other than 25–70 GSM)
2	560312	Nonwovens, whether or not impregnated, coated, covered or laminated, n.e.s., of man-made filaments, weighing > 25 g/m² but <= 70 g/m² (non-woven fabrics of 25–70 GSM)
3	560314	Nonwovens, whether or not impregnated, coated, covered or laminated, n.e.s., of man-made filaments, weighing > 150 g (non-woven fabrics other than 25–70 GSM)
4	560391	Nonwovens, whether or not impregnated, coated, covered or laminated, n.e.s., weighing <= 25 g/m² (excluding man-made filaments) (non-woven fabrics other than 25–70 GSM)
5	560392	Nonwovens, whether or not impregnated, coated, covered or laminated, n.e.s., weighing > 25 g/m² but <= 70 g/m² (excluding man-made filaments) (non-woven fabrics of 25–70 GSM)
6	560393	Nonwovens, whether or not impregnated, coated, covered or laminated, n.e.s., weighing > 70 g/m² but <= 150 g/m² (excluding man-made filaments) (non-woven fabrics other than 25–70 GSM)
7	560394	Nonwovens, whether or not impregnated, coated, covered or laminated, n.e.s., weighing > than 150 g/m² (excluding man-made filaments) (Non-woven fabrics other than 25–70 GSM)

Medical and Non-medical Wearables (Final Products)

Sl No.	HS Code	Description
1	392690	Articles of plastics and articles of other materials of heading 3901 to 3914, n.e.s. (medical coverall (PPE kits), nitrile/NBR gloves)
2	401511	Surgical gloves, of vulcanised rubber (excluding finger stalls) (surgical rubber or medical examination rubber gloves)
3	621790	Parts of garments or clothing accessories, of all types of textile materials, n.e.s. (medical coverall (PPE kits), N 95 masks, medical coverall (PPE kits))
4	630790	Made-up articles of textile materials, incl. dress patterns, n.e.s. (non-medical coverall (PPE Kits), face shields, N 95 Mask)

(Appendix A continued)

(Appendix A continued)

Disinfectants and Sterilisation Products		
Sl No.	HS Code	Description
1	300215	Immunological products, put up in measured doses or in forms or packings for retail sale (COVID-19 Test kits (blood, antisera, vaccines, toxins and cultures, swabs))
2	380894	Alcohol-based hand sanitiser and other disinfectant preparations
3	701010	Glass ampoules (glass containers for vaccines)
4	701090	Carboys, bottles, flasks, jars, pots, phials and other containers, of glass, of a kind used for the commercial conveyance or packing of goods, and preserving jars, of glass (glass containers for vaccines)
5	841990	Parts of machinery, plant and laboratory equipment, whether or not electrically heated, for the treatment of materials by a process involving a change of temperature n.e.s. (15 ml Falcon tube or Cryovials)
Medical Devices and Equipment		
Sl No.	HS Code	Description
1	841920	Medical, surgical or laboratory sterilisers
2	901811	Electro-cardiographs
3	901812	Ultrasonic scanning apparatus (ultrasound machines)
4	901819	Electro-diagnostic apparatus, incl. apparatus for functional exploratory examination (multiparametric patient monitoring devices/pulse oximeters)
5	901839	Needles, catheters, cannulae and the like, used in medical, surgical, dental or veterinary sciences (excluding syringes, tubular metal needles and needles for sutures) (medical and surgical instruments and apparatus)
6	901850	Ophthalmic instruments and appliances, n.e.s.
7	901890	Instruments and appliances used in medical, surgical or veterinary sciences, n.e.s. (intubation kit)
8	901920	Ozone therapy, oxygen therapy, aerosol therapy, artificial respiration or other therapeutic respiration apparatus (ventilators, oxygen humidifiers/flow splitter/CPAP/BIPAP/oxygen concentrators)
9	902000	Other breathing appliances and gas masks, excluding protective masks having neither mechanical parts
10	902212	Computer tomography apparatus (Medical and surgical instruments and apparatus (CT scanners))

Source: Authors' Compilation from GOI (n.d.).

(Table A2 continued)

(Table A2 continued)

Table A2. List of Issues Covered in the Primary Survey Questionnaire.

Category	Sl No.	Issues
Operational		
	1	Ability to scale up vaccine production for instance acquiring specialised capital equipment such as bioreactors and filtration pumps, and access to critical inputs such as lipid nano-particles and skilled labourers.
	2	Ability to scale up specialised assembly-line capital equipment and variable inputs such as glass vials and stoppers.
	3	Cooperation and collaboration among multiple stakeholders including public health officials, government agencies, pharmaceutical manufacturers and distributors among others.
	4	Government regulations delay permission for domestic pharma companies to start contract vaccine manufacturing in India.
	5	Vaccine hesitancy results from a lack of awareness and understanding of the vaccines.
Financial		
	1	Higher shipment cost for APIs resulting from shipping container shortage during the second wave of COVID-19.
	2	Steep rise in prices of Chinese APIs at the time of heightened demand during the second wave of COVID-19.
	3	The US embargo on exporting COVID vaccine raw materials during the second wave of COVID-19.
	4	Higher tariffs cost escalating the price of medicines, vaccines, and medical equipment.
	5	Higher costs associated with compliance of procedures and NTMs, escalating the price of medicines and vaccines.
	6	Infrastructural issues such as congested and poor road conditions lead to cost escalation.
Logistic		
	1	Availability of cold storage facilities for vaccines in PHC, CHC and CGHS.
	2	Availability of RT PCR testing facilities in PHC, CHC and CGHS.
	3	Availability of needles, syringes, antiseptic wipes, and other pharmaceutical ingredients needed for administering vaccines.
	4	Maintaining temperature control while storing vaccines.
	5	Maintaining temperature control while transporting vaccines.
	6	A digital presence in rural India to spread awareness about COVID-19 vaccination.

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Notes

1. On 28 January 2021, in his address to the Davos Dialogue, World Economic Forum Prime Minister Mr Narendra Modi announced that India has successfully controlled COVID-19. However, with a sudden surge in cases, India recorded 4,14,433 new COVID-19 cases on 6 May 2021, accounting for one in every two infections and one in every four deaths recorded worldwide (Our World in Data, 2021).
2. API are chemicals used to make medicines of any form, such as tablets, liquids, ointments, injectables, or infusion drugs. API is also referred to as a bulk drug.
3. As per Foreign Trade Policy (2015–2020), GOI, exporters are entitled to get back, "2 per cent/3 per cent/5 per cent/7 per cent of FOB value of notified goods exported to notified markets in free foreign exchange or FOB value of exports as given in the Shipping Bills in free foreign exchange, whichever is less" (GOI, 2015).
4. Formulations are tablets, capsules, syrups, drops, and intravenous fluids (injections) available in the market and are made up of API (bulk drug) and inactive pharmaceutical ingredients (other intermediate inputs).
5. In the GOI notifications, often the export restriction on a particular API/medicine has been indicated by naming the specific bulk drug, for example, Vitamin C, against the corresponding HS 6-digit code (i.e., HS 293627). Therefore, the product descriptions in Appendix A include both the HS classifications as well as the corresponding GOI depictions within brackets. While a particular HS 6-digit code thus covered under the current analysis may include other APIs apart from the specifically mentioned COVID-19-related bulk drug, the RCA-RCDA-trade balance figures underline India's comparative advantage in the closely related product segment.
6. India signed six different RTAs, namely (a) South Asian Free Trade Area in 2006, (b) India Bhutan Trade Agreement in 2006, (c) India Chile Preferential Trade Agreement (PTA) in 2007, (d) India MERCOSUR PTA in 2009, (e) India-ASEAN FTA in 2010 and (f) India South Korea Comprehensive Economic Partnership Agreement (CEPA) in 2010.
7. India signed 2 RTAs, namely (a) India Japan CEPA and (b) India Malaysia Comprehensive Economic Cooperation Agreement in 2011. While the country started participating in the Regional Comprehensive Economic Partnership in 2013 onwards, it pulled out of the forum in 2019, citing reservations over coverage of reforms and tariff reduction schedule.
8. As a part of the Atmanirbhar Bharat Abhiyan initiative, Finance Minister Nirmala Sitharaman in her 2021–2022 budget announced a PLI scheme that shortlisted dozens of pharmaceutical products where Chinese manufacturers had a strong influence on supplies and prices. The success of the scheme however has been modest and the need for modification of the same has been suggested (Joseph and Kumar, 2021).
9. The process for developing a new vaccine and medicine, involves five distinct phases, namely, research and development, clinical trials, transforming the drug substance and formulation into vaccines and medicines, product packaging involving putting the vaccines into vials, or medicines into aluminium foil, and finally distribution. As the focus of this study is on India, we do not consider all the stages of the supply chain involved in developing a new vaccine and medicines. As Indian pharma companies obtained licenses to manufacture vaccines, we confine our study involving the last three phases.

10. It may be noted that all the corporate executives from the pharmaceutical companies interviewed for the purpose of the analysis have more than 10 years of experience. Some executives are engaged as General Managers or assigned positions of greater responsibility.

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