

## KEY POINTS

- Since the COVID-19 outbreak, the supply chain for personal protective equipment (PPE) has not adequately functioned to meet the surge in demand. Constraints in supply and logistics, including export bans for PPE and key materials, have come into stark focus.
- Abrupt supply disruptions in the People's Republic of China (PRC), the major producer of PPE in the global trade network and the first country to be hit by the coronavirus, are having spillover impacts on Asia and the rest of the world.
- Trade restrictions and export bans in more than 20 economies also exacerbate the problems in PPE production and distribution.
- Reorienting manufacturers of nonmedical devices for PPE production is among the extraordinary measures being taken to end bottlenecks in supply. But more actions are needed.
- Multilateral development banks including the Asian Development Bank are well-placed to help increase PPE production and logistics capacity; strengthen supply chain and trade finance programs; and target aid to support vulnerable groups such as women, children, and the elderly.

## Global Shortage of Personal Protective Equipment amid COVID-19: Supply Chains, Bottlenecks, and Policy Implications<sup>1</sup>

### DISRUPTIONS TO GLOBAL SUPPLY OF PERSONAL PROTECTIVE EQUIPMENT

The COVID-19 pandemic is rapidly spreading across countries and regions, causing huge impact on people's lives and communities. Starting as a health crisis, it now poses serious threats to the global economy, trade, and finance, with the estimated economic impacts to range between \$2 trillion and \$4.1 trillion globally (ADB 2020a). Surging demand, partly joined with panic buying, hoarding, and misuse of personal protective equipment (PPE) amid the COVID-19 pandemic, is disrupting global supplies and putting lives at risk. Demand has surged, overwhelming global production capacity. The dramatic rise in demand for surgical masks, goggles, gloves, and gowns has depleted stockpiles, prompted significant price increases, and led to production backlogs of 4–6 months in fulfilling orders. The most significant challenge is to ensure that critical PPE products are sourced and allocated to frontline health workers and other responders in affected countries, especially those most vulnerable to the spread of the coronavirus.

The World Health Organization (WHO) estimated that 89 million medical masks are required for the COVID-19 response each month, along with 76 million examination gloves and 1.6 million medical goggles (WHO 2020). WHO itself has so far shipped nearly half a million sets of personal protective equipment to 47 countries, but supplies are depleting rapidly. To meet rising global demand, WHO estimates that industry must increase manufacturing by 40% and urges governments to act quickly to boost supply.

### UNDERSTANDING HOW SUPPLY CHAINS OPERATE IS CRUCIAL

Supply chain disruptions for PPE are particularly risky for medical personnel as COVID-19 rapidly spreads. If not adequately protected, healthcare workers who are the frontline defense against coronavirus can infect patients or colleagues, and

<sup>1</sup> The authors of this brief are Cyn-Young Park, Kijin Kim, Susann Roth, Steven Beck, Jong Woo Kang, Mara Claire Tayag (Asian Development Bank); and Michael Griffin (World Health Organization). Research support was provided by Joshua Anthony Gapay, Benjamin Endriga, Marife Lou Bacate, Zemma Ardaniel, Ana Kristel Lapid, Concepcion Latoja, and Clemence Fatima Cruz.

the need to be quarantined after exposure quickly depletes the health workforce. Medical supply chains are essential elements of a well-functioning health system. To respond to infectious disease outbreaks effectively, health supply systems should be designed to swiftly and reliably source and deliver essential health commodities, including vaccines, medicines, and PPE for healthcare workers, which are needed during outbreaks, epidemics, and pandemics.

The ongoing coronavirus pandemic exposes the vulnerabilities of supply chains across many industries. Over the past few years, healthcare systems in many countries have encouraged or forced the offshoring of PPE production to low-cost providers. In the United States (US), 95% of surgical masks and 70% of respirators are produced overseas (Flynn 2020). Amid the COVID-19 outbreak in the People's Republic of China (PRC), factory shutdowns and bans on travel and PPE exports have put significant strain on PPE supply chains, while the evolving pandemic nature of COVID-19 leads to political and technical constraints in supplying the market. To improve inventory management efficiency, the just-in-time system has been implemented worldwide for materials critical for PPE products, resulting in an overall reduction in national stocks. Since this contrasts with the idea of pandemic planning and stockpiling, it has caused PPE stocks to be insufficient to meet the surge in demand for PPE during disease outbreaks (ICT 2008).

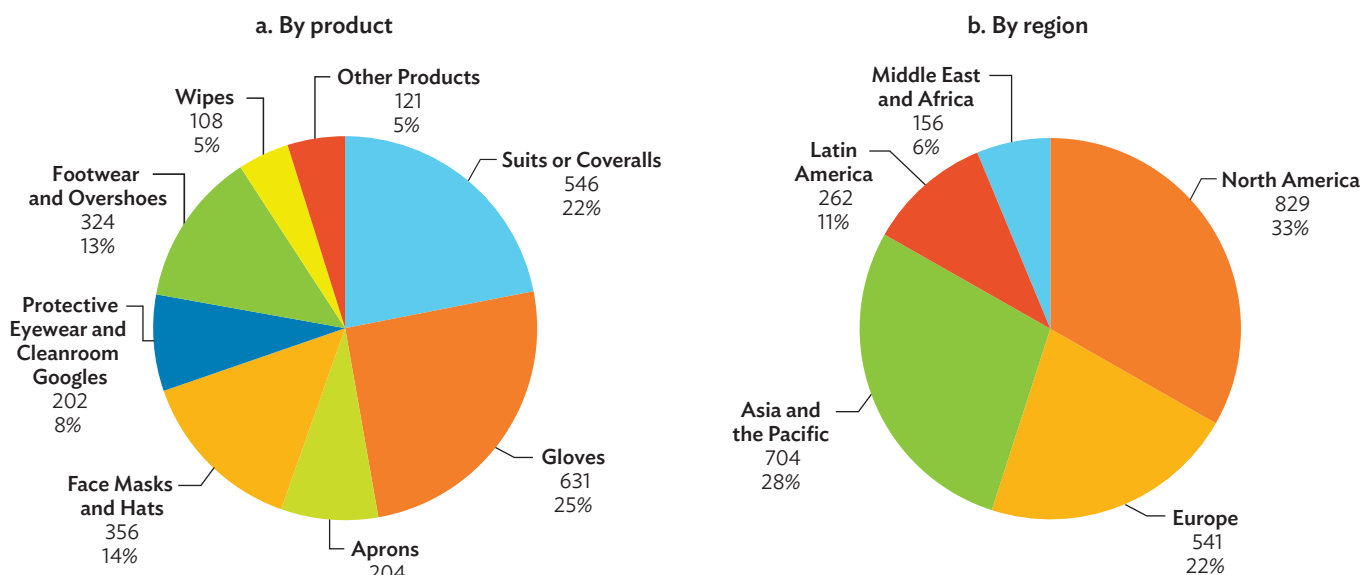
## PPE Market Overview

PPE and pharmaceutical manufacturing in Asia and the Pacific is significant. Prominent producers operate in the PRC, while India meets about 20% of global demand for medicines and vaccines, the Republic of Korea remains among the most significant pharmaceutical manufacturing markets, and Singapore is a regional hub for international pharmaceutical companies (Mordor Intelligence 2020).

PPE is clothing and equipment designed to protect the wearer from injury or spread of infection. Key PPE items—including N95 masks, surgical masks, gowns, and goggles—are essential for healthcare workers. Most of the raw materials and inputs used to produce PPE are outsourced to low-cost suppliers. Production of these items often requires imports of raw materials such as cotton fiber, polyester, and polyamide produced by different manufacturers around the world. These are processed by protective clothing manufacturers for sale to end users.

The global market for PPE in the health sector was estimated to be worth \$2.5 billion in 2018. Gloves have the highest share of sales revenues at 25%, followed by suits or coveralls at 22%. Face masks and hats came in third with a share of 14% (Figure 1). By region, the US had the largest market share (33%), followed by Asia and the Pacific (28%), and Europe (22%) in 2018 (Mordor Intelligence 2020).

Figure 1. Market Share by PPE Product and Region, 2018 (revenue \$ million, %)



PPE = personal protective equipment.  
Source: Mordor Intelligence (2020).

The greatest concentration of mask production is in the PRC, reportedly accounting for about half the global production capacity. Some sources indicate it could be even as much as 80%–90%. For gloves that comply with WHO standards, the distribution of manufacturing capacity is more diverse. Although the PRC produces significant amounts of gloves, the greatest production capacities are in Indonesia, Malaysia, and Thailand. Small production capacities are scattered across various countries such as the Philippines and Turkey. Any increase in production capacity is estimated to be between 20% and 40% with a ramp-up period of about 3–4 months. In many smaller countries, however, quality assurance standards do not meet WHO technical specifications.

## Snapshot of PPE Supply Chains Based on Trade Flows

Given the complexity of PPE products and supply chains, this brief provides only a snapshot of select supply chains of PPE products in critical shortage, making the most of publicly available information. Figure 2 presents global trade networks for six kinds of PPE based on the 6-digit Harmonized System (HS) codes: (i) HS 630790 including surgical masks; (ii) HS 392690 including respirators; (iii) HS 621010 including surgical gowns; (iv) HS 392620 including protective suits; (v) HS 900490 including protective goggles; and (vi) HS 401511 including surgical gloves.<sup>2</sup> The size of the circles represents total trade of the item, and the thickness of the lines denotes the importance of bilateral trade flows between economies.

The trade network maps show high geographic and regional concentration in the PPE supply chain. Three regional clusters emerge: Asia, Europe, and the US. While the PRC, Germany, and the US are the main producers, the PRC appears to play a central role in producing and exporting many PPE products to Asia and the rest of the world. In particular, the PRC emerges as the world's largest exporter in commodity groups that include masks, gowns, protective suits, and goggles. Malaysia is the top exporter of surgical gloves in the world, followed by Thailand and the PRC. Within Europe, major PPE suppliers are Belgium, France, Germany, Italy, the Netherlands, and Poland. Other European countries import from these countries and from the PRC. Although the US is the largest buyer of PPE produced in the PRC (and of gloves from Malaysia), it is still the major producer and at the core of the regional supply value chain for many PPE products in North and South America.

Abrupt, large supply disruptions from the PRC, as the major supplier in the trade network, will have spillover impact throughout the world. Trade restrictions and export bans also exacerbate the stresses in PPE production and supplies. Given the PRC's strong centrality in the regional PPE supply chain, supply disruptions from the PRC will likely have a substantial impact on regional supplies.

On the other hand, Europe has its own regional capacity with sources of PPE somewhat diversified among suppliers. This may help the region withstand to an extent the supply shock originating from Asia. However, production capacity in Europe is unlikely to meet a demand surge associated with the rapid spread of COVID-19. The US also depends heavily on overseas production and is expected to face a critical shortage of PPE.

## SOURCES OF SIGNIFICANT SUPPLY CHAIN BOTTLENECKS

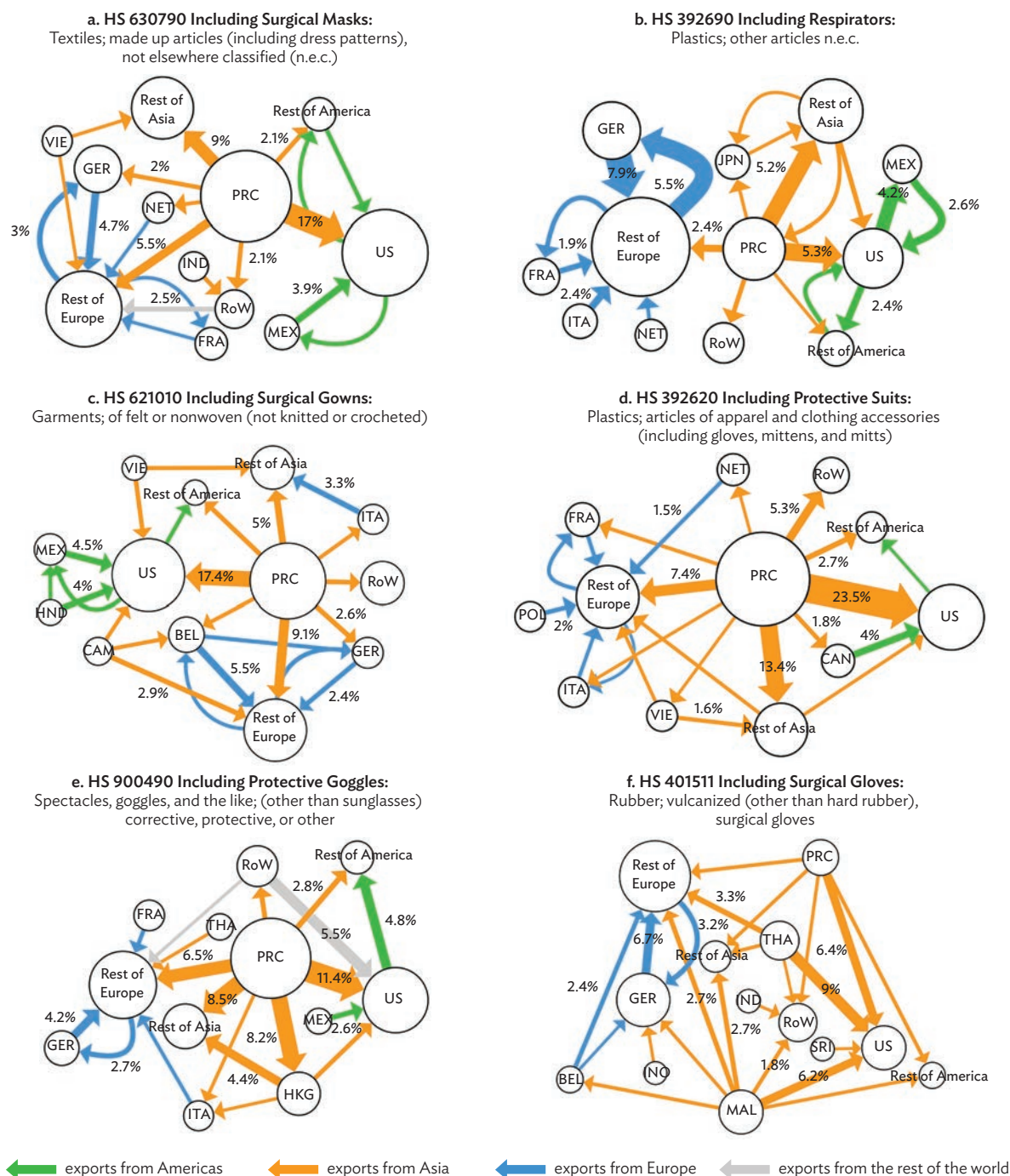
The PPE supply chain has not been properly functioning to meet a surge in demand due to the constraints in production and logistics. Prices of PPE products have risen dramatically since the beginning of the COVID-19 outbreak: a sixfold increase for surgical masks; threefold for respirators; and a doubling in the price of gowns (WHO 2020). There is a backlog of 4–6 months for supply orders globally, and raw materials are running short. Export bans for PPE and key materials are being implemented in many economies.

Below are major sources of the identified backlogs in the production and distribution of PPE, with a focus on face masks (also shown in Figure 3).

- **Raw materials.** A surge in demand for N95 masks has led to a shortage of the key component, nonwoven polypropylene. In the PRC, the shortage of melt-blown fabric is a serious bottleneck in downstream processes for making high-level N95 masks.
- **Machines.** There is a bottleneck of melt-blown production lines, and building the production line also takes time. For example, it takes about half a year at least to assemble a single machine production line to make melt-blown fabric.
- **Geographic concentration of manufacturers.** The high dependence on the PRC as a production hub is also a factor so that worker quarantines led to manufacturer shutdowns. The PRC accounted for half the global supply of masks, with a daily production of about 20 million units before the outbreak.
- **Export bans.** The global shortage of face masks has also been worsened by export bans of masks and key materials in various economies, including Bangladesh; Canada; Czech Republic; Egypt; France; Germany; India; Indonesia; Iran; Japan; Jordan; Kazakhstan; Kenya; Malaysia; Pakistan; Poland; the PRC; the Russian Federation; the Republic of Korea; Taipei, China; Thailand; and Ukraine. As of 18 March 2020, export bans were in place in 22 economies.
- **Other bottlenecks.** Transport and shipping constraints caused by roadblocks and quarantine measures, and lower availability of transportation and freight containers, hoarding, profiteering, and limited workforce capacity due to illness, also contribute to the shortage.

<sup>2</sup> It should be noted that there are some caveats in this approach. The 6-digit commodity codes used here are still highly aggregated and may include other items. The specific items are identifiable at the 8–10 digit codes but its classification varies significantly among the tariff schedules of different economies, hence the same items may appear in multiple commodity groups.

Figure 2. Global Trade Networks of Select PPE Products, 2018



BEL = Belgium; CAM = Cambodia; CAN = Canada; FRA = France; GER = Germany; HKG = Hong Kong, China; HND = Honduras; HS = Harmonized System; IND = India; INO = Indonesia; ITA = Italy; JPN = Japan; MAL = Malaysia; MEX = Mexico; NET = Netherlands; POL = Poland; PPE = personal protective equipment; PRC = People's Republic of China; RoW = rest of the world; SRI = Sri Lanka; THA = Thailand; US = United States; VIE = Viet Nam; n.e.c. = not elsewhere classified.

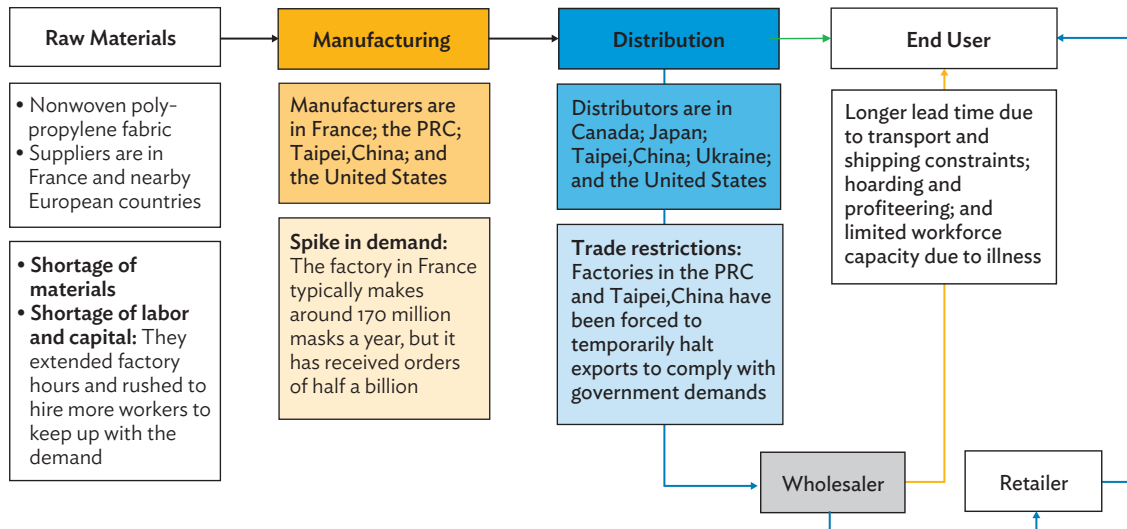
Notes: The size of the nodes represents the economy's total trade (exports plus imports) of the concerned commodity group. The thickness of the lines represents the value of the flow of goods between economies. Some lines show the share of exports to the total global exports of the commodity group. For clarity, only exports with high values are represented by the lines.

Source: ADB calculations using data from United Nations. Commodity Trade Database. <https://comtrade.un.org> (accessed 22 March 2020).



Figure 3. An Illustration of PPE Supply Chain Bottlenecks

This figure illustrates the case of face masks produced by Medicom, Inc., a PPE manufacturer based in Canada with offices in the United States; the Netherlands (European arm); and Hong Kong, China (Asian arm)



PPE = personal protective equipment, PRC = People's Republic of China.

Sources: Asian Development Bank based on Alderman (2020), Feng and Cheng (2020), Hufford and Evans (2020), Henneberry (n.d.).

## RESPONSES TO PPE SUPPLY CHAIN BOTTLENECKS

### Country Responses

Countries are urgently implementing measures to help firms expand production capacity. The Government of the PRC introduced measures to support production of face masks by aiding the purchase of raw materials and the hiring of workers as well as offering tax breaks for manufacturers. The PRC produces 200 million face masks a day—more than 10 times what it made at the start of February 2020. Local authorities have granted new licenses to allow more factories to produce masks, including high-grade ones used by healthcare professionals, while a local government has invested about \$507,000 to help companies buy medical materials. In Japan, the government provided support for companies to increase capital investment in mask production, while securing supply of over 600 million masks per month (Ministry of Trade, Economy, and Industry of Japan 2020).

Extraordinary measures have been taken to ramp up production capacity by reorienting the manufacturers of nonmedical device for PPE production. In the PRC, automobile companies have been asked to produce masks and other types of PPE. SAIC-GM-Wuling, for instance, a General Motors Co. venture, has built 14 production lines for masks with a daily capacity of 1.7 million masks. Truckmaker Shaanxi Automobile Group Co. has

started producing goggles with 3,000 units of daily capacity. The smartphone maker Xiaomi has also been producing thermometers and other equipment (Bloomberg 2020). In the United Kingdom, more than 60 manufacturers including Airbus, Jaguar Land Rover, and Rolls-Royce have been sent blueprints for manufacturing up to 20,000 ventilators for COVID-19 patients (Davies 2020). Major automakers in the US, such as Ford and General Motors, are also working with medical device manufacturers to increase the production of ventilators and respirators (Bushey, Edgecliffe-Johnson, and Stacey 2020).

### ADB Support in the COVID-19 Fight

The Asian Development Bank (ADB) supports its developing member countries (DMCs) in responding to the pandemic and the related crisis through finance, knowledge, and partnerships. ADB is following a three-pronged approach: (i) support countries' immediate needs to respond to the pandemic and its secondary effects; (ii) strengthen sector-wide pandemic preparedness, stabilize the economies, and strengthen health systems; and (iii) address systemic constraints limiting effective responses, working with the private sector and international organizations like the United Nations.

As of 3 April 2020, ADB has committed to providing more than \$6.8 billion, including an initial support package of \$6.5 billion for sovereign and nonsovereign operations while more resources are expected be mobilized. Many of these measures aim to provide

fiscal support to address the immediate needs of developing Asia in responding to high demand for medical goods and devices for detection and protection and to strengthen national health systems (Table 1).

Among these measures, the Supply Chain Finance Program is dedicating \$200 million to support companies that make and distribute medicines and other items needed to combat COVID-19, which falls in the third category (ADB 2020b). The program aims to contribute to stabilizing the supply chain for products to protect against COVID-19, including N95 masks, COVID-19 test kits, gloves, PPE for healthcare providers, ventilators, hygiene items, and the like (collectively called COVID-19 Critical Goods). ADB assistance is targeted at channeling fund to manufacturers, their

suppliers, and the distributors of critical goods through post-shipment post-acceptance finance, pre-shipment loans, and distributor financing (Figure 4).

An \$800-million increase in ADB's Trade Finance Program will also be mobilized. Along with the increase in capital comes flexibility to support domestic and cross-border trade in times of emergency.

The program is an effective crisis response vehicle because it has strong relationships with many banks, both inside developing Asia and globally, the latter particularly helpful to mobilize cofinancing, involving private sector resources to leverage the impact of ADB's direct support. These ties with banks through the program enable fast and effective support through local banking systems.

**Table 1. Asian Development Bank's Responses to the COVID-19 Outbreak**

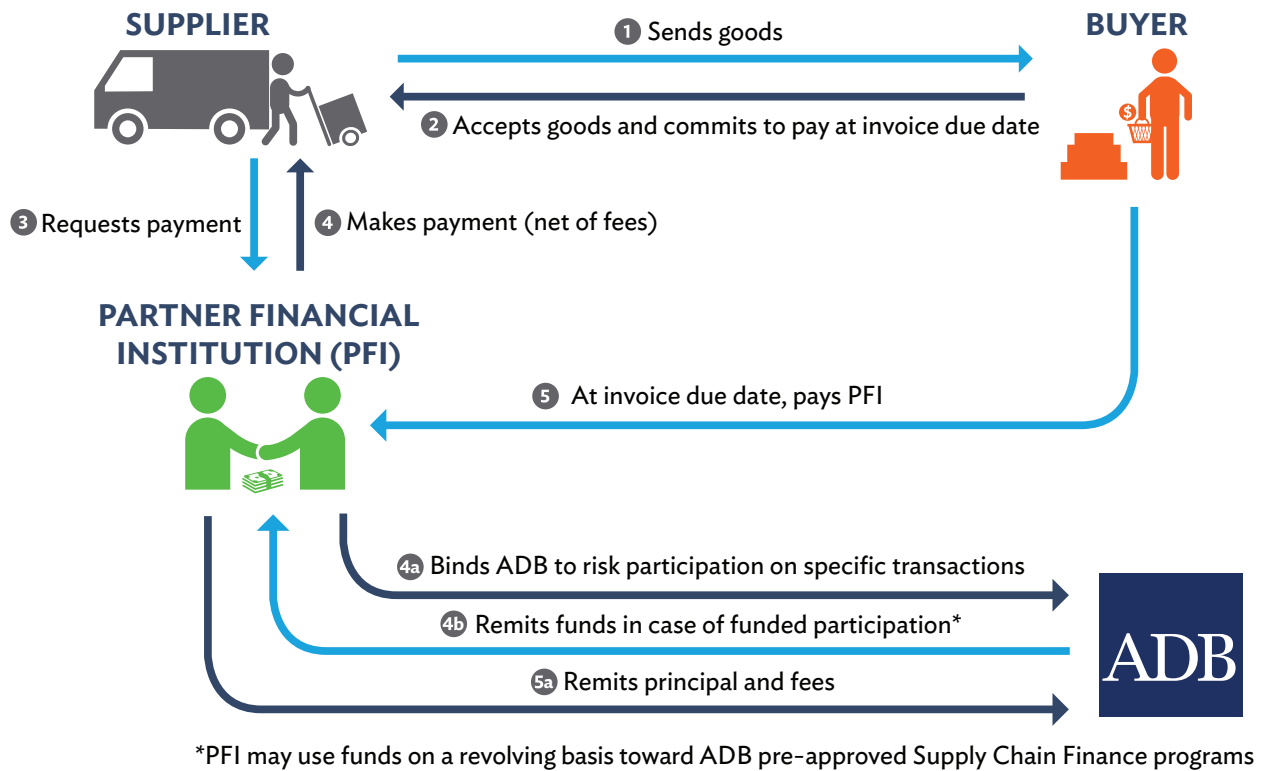
Project	Date	Target DMCs	Amount (\$)
Strengthening Regional Health Cooperation in the Greater Mekong Subregion (supplementary)	7 Feb 2020	GMS	2 m
GMS Health Security Project*	27 Jan–17 Feb 2020	GMS	1.5 m
COVID-19 Emergency Response Project	25 Feb 2020	PRC	8.6 m
Regional Support to Address the Outbreak of Coronavirus Disease 2019 and Potential Outbreaks of Other Communicable Diseases	26 Feb 2020	DMCs	2 m
Supply Chain Finance Program	12 Mar 2020	DMCs	200 m
Health System Enhancement Project*	13 Mar 2020	Sri Lanka	600,000
Maternal and Child Health Integrated Care Project*	13 Mar 2020	Tajikistan	100,000
Asia-Pacific Disaster Response Fund	14 Mar 2020	Philippines	3 m
Fifth Health Sector Development Project *	18 Mar 2020	Mongolia	1.4 m
Support for Improving the Preparedness and Response to Novel Coronavirus Outbreak	18 Mar 2020	Mongolia	225,000
Initial support package	18 Mar 2020	DMC	6.5 b
Asia-Pacific Disaster Response Fund	21 Mar 2020	Indonesia	3 m
Asia-Pacific Disaster Response Fund	21 Mar 2020	Maldives	500,000
Asia-Pacific Disaster Response Fund	26 Mar 2020	Mongolia	1 m
Asia-Pacific Disaster Response Fund	30 Mar 2020	Pakistan	2 m
Private sector financing	31 Mar 2020	PRC	20 m
Asia-Pacific Disaster Response Fund	1 Apr 2020	Federated States of Micronesia, Marshall Islands, Nauru, and Tuvalu	1.53 m
Rapid Emergency Supplies Provision Project	1 Apr 2020	Philippines	5 m
Regional Support to Address the Outbreak of Coronavirus Disease 2019 and Potential Outbreaks of Other Communicable Diseases	2 Apr 2020	Sri Lanka	100,000

\*Reallocated from the existing ADB project; Date is the news release date.

b = billion, DMC = developing member country, GMS = Greater Mekong Subregion, m = million, PRC = People's Republic of China.

Source: Asian Development Bank. ADB's Response. <https://www.adb.org/what-we-do/covid19-coronavirus> (accessed 3 April 2020).

Figure 4. How the Supply Chain Finance Program Works



Source: Asian Development Bank. Supply Chain Finance Program. <https://www.adb.org/site/trade-finance-program/scfp>.

## POLICY IMPLICATIONS

### Lessons from Past Experience

Recent epidemics and pandemics, including the 2009 H1N1 influenza pandemic and the 2014 Ebola virus epidemic, provide important lessons in improving readiness of PPE supply. Transparent and comprehensive information about availability of products on the market, production capacity, and supply response is critical for PPE readiness during these outbreaks, epidemics, and even more so for pandemics. Ensuring guidance on appropriate use of PPE (through proper care, maintenance, and disposal) also proved to be helpful to avoid wastage. The absence of a systemwide mechanism to track the amount of PPE circulating in markets and in use and to centrally monitor the orders to support future preparedness was a key challenge. Lessons gleaned from the past experience suggest some strategies as follows (Patel et al. 2017):

- **Monitoring PPE use and distribution and centralizing visibility of orders placed.** This will help to safeguard effective delivery of patient care during an emergency response, and allow distributors and manufacturers to better detect duplicate

orders and forecast product demand at national, regional, and global levels. Surge capacity can be facilitated, while trade and logistics support can be prioritized during pandemics.

- **Improving just-in-time supply system and sharing responsibility.** Stockpiles (international, national, and local) should be designed to address demands of an acute outbreak, epidemic, and pandemic while production capacity can be raised to meet needs for PPE supply. For outbreaks in one country it is much easier to source additional supplies from other countries, but during pandemics such management is difficult since all countries are affected.
- **Improving domestic manufacturing surge capacity at the time of an event.** Government health systems must be tested before epidemics or pandemics happen.
- **Sharing information and communicating regularly.** An efficient, low-burden mechanism for governments and private sector partners to share situational and supply information needs to be developed.

Although lessons from the past are highly relevant, it is important to reinforce efforts to address the supply chain disruption of PPE under new circumstances. Worldwide supply chain networks have been a

key feature of globalization from which multinational corporations seeking low-cost supplies have benefited mostly. Offshoring, lean manufacturing, and just-in-time inventory—proven measures to cut costs—may have stretched the global supply chain to a breaking point in times of stress. These business practices now make the companies extremely vulnerable to disruptions in parts of the supply chain or where trade restrictions are in place.

After the crisis is over, countries may want to consider maintaining adequate PPE stocks and enough surge capacity to be able to ramp up national production. For now, it is important for countries to work together to improve resource allocation and production capacity within and across borders. Given the interdependence along the supply chain network, countries should lift export bans and trade restrictions on key materials and PPE and streamline the cross-border logistics of these types of freight. As countries will likely face different infection curves at any given time, efficient resource allocation at a global scale will help support the national health security of individual countries while minimizing strains on limited domestic resources.

### The Role of Multilateral Development Banks

The COVID-19 pandemic exposes the weakest or weaker links in the PPE supply chain. Given the acute global shortage of PPE, swift international support and cooperation for building a seamless pipeline to ensure continuity of supply is critical. Multilateral development banks including ADB should provide support on the following three fronts:

**Help increase national PPE production and logistics capacity and regional cooperation.** ADB can provide funding and assistance to increase investment aimed at increasing production and capacity throughout the supply chain for PPE. ADB can incentivize public-private partnerships to develop efficient and effective production and logistics strategies so that PPE supplies are directed to those in critical need, including healthcare workers. This includes developing local production capacity and mobilizing the diverse sources of supply for PPE needs during outbreaks in DMCs. Financing mechanisms are available but need to be expanded. Countries need guarantees to make advanced payments for supplies.

Regional cooperation mechanisms across subregions and economic cooperation clusters should be upscaled. The public goods aspect of secure PPE supply chain under pandemic conditions underpins the call for strengthening the role of regional institutions in regional or global mechanisms for epidemic and pandemic response. By strengthening collaboration with established mechanisms like the Pandemic Supply Chain Network coordinated by WHO, multilateral development banks can play a role in effective coordination with member countries at the regional level. It is essential to acquire national and local supply chain market information and share it with the members in the common regional network so that they can manage timely and

more efficient responses at the onset of a disease outbreak and mitigate the spread beyond the initial outbreak.

**Strengthen supply chain and trade finance programs for MSMEs.** Micro, small, and medium-sized enterprises (MSMEs) are particularly vulnerable to the economic and trade impact of COVID-19. Many of the PPE and supply manufacturers in the region are also MSMEs. Some may be forced to close their businesses and lay off their employees, while many are facing difficulty with their cash flow. Surveys in Asia report that many small businesses are experiencing supply chain disruptions, sales and trade reductions, and liquidity and working capital constraints. Trade finance programs should also help facilitate trade of MSMEs in the supply chain (Myers 2020; AuManufacturing 2020; The Times of India 2020). ADB's Trade Finance Program and Supply Chain Finance Program have more roles to play in financing MSMEs in developing economies to support their domestic and international trade.

However, experts recognize that procurement of supply is a bigger challenge than financing. Globally, the WHO-led Pandemic Preparedness Network (PPN) is working on political solutions to lift export bans and on rationalization of the trade and supply of key materials so that countries get supply allocation based on epidemiological profiles (incidence of disease and country risk profile) and for developing countries to get much-needed supplies. The PPN procures on behalf of partners like the World Bank and countries across the world, bringing attention to the failure of markets to deliver PPE supplies. The PPN is also helping countries with demand projections and mediating between buyers and sellers in a transparent manner and organizing logistics in the face of flight bans. For complicated supplies like ventilators, countries are looking into leasing and using refurbished ones; and it is important to ensure capacity is available to operate machines.

**Target aid to support vulnerable groups.** ADB can swiftly provide a range of grants and concessional financing for programs targeted at vulnerable groups such as women, children, and the elderly. There are growing concerns that COVID-19 would disproportionately affect women. A majority of healthcare professionals and workers are female. For example, women account for 60% of healthcare jobs in South and Southeast Asia.<sup>3</sup> In particular, women make up about 80% of the nursing workforce where PPE supply is critical because patient interactions are intense. More broadly, women are often the primary caregivers for families. Should national healthcare systems get stretched due to widespread infections, many patients will have to be cared for at home. Caring for the sick in the family will add to the burden, while increasing the risk of infection for women. The poorest and most vulnerable people are likely to be more exposed to infection risks, job and income losses, and suffer more inadequate medical treatment. Aid can further support in providing PPE to community health centers and public clinics that are playing a critical frontline role for these groups.

<sup>3</sup> The figures are based on the national force survey data in seven countries: Bangladesh, India, Indonesia, the Philippines, Sri Lanka, Thailand, and Viet Nam.



### REFERENCES

- Alderman, L. 2020. As Coronavirus Spreads, Face Mask Makers Go Into Overdrive. *The New York Times*. 29 February. <https://www.nytimes.com/2020/02/06/business/coronavirus-face-masks.html?action=click&module=RelatedLinks&pgtype=Article>.
- Asian Development Bank (ADB). 2020a. *Asian Development Outlook 2020: What Drives Innovation in Asia?*. Manila.
- ADB. 2020b. ADB to Provide \$200 Million to Support Strained Supply Chains in Fight Against COVID-19. News Release. 12 March. <https://www.adb.org/news/adb-provide-200-millionsupport-strained-supply-chains-fight-against-covid-19>.
- AuManufacturing. 2020. Coronavirus, Bushfires, Drought Contribute to Biggest Drop in Manufacturing Conditions in Two Decades: Survey. 19 March. <https://www.aumanufacturing.com.au/coronavirus-bushfires-drought-contribute-to-biggest-drop-in-manufacturing-conditions-in-two-decadessurvey>.
- Bloomberg. 2020. Chinese Carmakers Are Now Making Face Masks, Prompted by Coronavirus. 10 February. <https://www.bloomberg.com/news/articles/2020-02-10/carmakers-moonlight-as-mask-manufacturers-to-fight-coronavirus>.
- Bushey, C., A. Edgecliffe-Johnson, and K. Stacey. 2020. Trump Invokes Federal Law to Compel General Motors to Make Ventilators. *Financial Times*. 28 March. <https://www.ft.com/content/9328d358-1588-4498-97d9-0dd43255a076>.
- Davies, R. 2020. UK Government Sends Ventilator Blueprints to Major Manufacturers. *The Guardian*. 16 March. <https://www.theguardian.com/business/2020/mar/16/vauxhall-owner-psa-car-shuts-european-plants-amid-coronavirus-fears>.
- Feng, E. and A. Cheng. 2020. COVID-19 Has Caused a Shortage of Face Masks. But They're Surprisingly Hard to Make. National Public Radio. 16 March. <https://www.npr.org/sections/goatsandsoda/2020/03/16/814929294/covid-19-has-caused-a-shortage-of-face-masks-but-theyre-surprisingly-hard-to-mak>.
- Flynn, S. 2020. INDUSTRY NEWS: Amid Coronavirus Fears, a Mask Shortage Could Spread Globally. Urgent Care Association. 24 March. <https://www.ucaoa.org/About-UCA/Industry-News/ArtMID/10309/ArticleID/1448/INDUSTRY-NEWS-Amid-Coronavirus-Fears-a-Mask-Shortage-Could-Spread-Globally>.
- Henneberry, B. (n.d.) How Surgical Masks are Made. Thomas. <https://www.thomasnet.com/articles/other/how-surgical-masks-are-made/>.
- Hufford, A. and M. Evans. 2020. Critical Component of Protective Masks in Short Supply. *The Wall Street Journal*. 7 March. <https://www.wsj.com/articles/coronavirus-pressures-supply-chain-for-protective-masks-11583552527>.
- Infection Control Today (ICT). 2008. US Pandemic Could Severely Strain Face Mask, Other PPE Supply Pipeline. 4 October. <https://www.infectioncontroltoday.com/personal-protective-equipment/us-pandemic-could-severely-strain-face-mask-other-ppe-supply-pipeline>.
- Ministry of Trade, Economy, and Industry (Japan). 2020. Seventeenth Meeting of the Novel Coronavirus Response Headquarters. 5 March. <https://www.meti.go.jp/english/covid-19/mask.html>.
- Mordor Intelligence. 2020. Protective Clothing Market for Life Sciences Industry (2019–2024). <https://www.mordorintelligence.com>.
- Myers, S. L. 2020. As Coronavirus Slams Small Business, a Noodle Shop Fights for Life. *The New York Times*. 27 February. <https://www.nytimes.com/2020/02/27/business/china-coronavirus-noodles-small-business.html>.
- Patel, A., M. M. D'Alessandro, K.J. Ireland, W.G. Burel, E.B. Wencil, and S. A. Rasmussen. 2017. Personal Protective Equipment Supply Chain: Lessons Learned from Recent Public Health Emergency Responses. *Health Security*. 15 (3). pp. 244–252.
- The Times of India*. 2020. 71% of Small Business See Demand Fall: Survey. 20 March. <https://timesofindia.indiatimes.com/business/india-business/71-of-small-biz-see-demand-fall-survey/articleshow/74720910.cms>.
- World Health Organization. 2020. Shortage of Personal Protective Equipment Endangering Health Workers Worldwide. News Release. 3 March. <https://www.who.int/news-room/detail/03-03-2020-shortage-of-personal-protective-equipment-endangering-health-workers-worldwide>.

### About the Asian Development Bank

ADB is committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 68 members—49 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

ADB Briefs are based on papers or notes prepared by ADB staff and their resource persons. The series is designed to provide concise, nontechnical accounts of policy issues of topical interest, with a view to facilitating informed debate. The Department of Communications administers the series.

#### Note:

ADB recognizes “China” as the People’s Republic of China.

The views expressed in this publication are those of the authors and do not necessarily reflect the views and policies of ADB or its Board of Governors or the governments they represent. ADB encourages printing or copying information exclusively for personal and noncommercial use with proper acknowledgment of ADB. Users are restricted from reselling, redistributing, or creating derivative works for commercial purposes without the express, written consent of ADB.

Asian Development Bank  
6 ADB Avenue, Mandaluyong City  
1550 Metro Manila, Philippines  
Tel +63 2 8632 4444  
Fax +63 2 8636 2444

[www.adb.org/publications/series/adb-briefs](http://www.adb.org/publications/series/adb-briefs)



Creative Commons Attribution 3.0 IGO license (CC BY 3.0 IGO)

© 2020 ADB. The CC license does not apply to non-ADB copyright materials in this publication.

<https://www.adb.org/terms-use#openaccess>    <http://www.adb.org/publications/corrigenda>    [pubsmarketing@adb.org](mailto:pubsmarketing@adb.org)