The Lakshmi Mittal and Family
SOUTH ASIA INSTITUTE
HARVARD UNIVERSITY

# Webinar: Science, Business, and Vaccine Development to Combat the Pandemic
## *Panelist Transcript*

**Moderator**

- **Tarun Khanna**, Jorge Paulo Lemann Professor, Harvard Business School; Director, The Mittal Institute

**Panelists**

- **Gagandeep Kang**, Executive Director, Translational Health Science and Technology Institute & Vice Chairperson of The Coalition for Epidemic Preparedness Innovations
- **Umang Vohra**, Managing Director & Global Chief Executive Officer, Cipla Ltd.
- **David E. Bloom**, Clarence James Gamble Professor of Economics & Demography, Harvard T.H. Chan School of Public Health

*Through the lens of a contemporary case study in the South Asia context, panelists will discuss the geopolitics of how vaccines are developed, the funding and distribution methods that are critical to the effort, and the global alliances that facilitate this in the world today.*

**BEGIN TRANSCRIPTION:**

**Inakshi Sobti:** Good evening and welcome. My name is Inakshi Sobti, it's wonderful to see participants join us from India, Pakistan, Sri Lanka, Bangladesh, Nepal, the Middle East, the US, even the Bahamas. On behalf of the Harvard Business School India Research Center and our faculty here in Boston, our esteemed colleagues from Harvard Business Publishing, the Lakshmi Mittal South Asia Institute, and our panelists, thank you for joining us.

Welcome to the second conversation in our webinar series 'Leadership Perspectives for a Changing World.' With over 7 million people diagnosed with Covid-19 and over 400,000 deaths globally, it is no surprise that all eyes are fixed with hope and anticipation on the scientific community and the pharmaceuticals industry. Today we have a stellar panel sharing their thoughts on how science and business are collaborating to develop vaccines and drugs to combat the pandemic. We do hope our series of conversations present research, potential frameworks and possible solutions that you can use as you navigate this space and with that I'd like to welcome Professor Tarun Khanna to set the context and introduce the panel.

**Tarun Khanna:** Thank you Inakshi, thank you team India Research Center and Mittal Institute. It's a pleasure to be here. We like to say that at Harvard, our mission is to educate the leaders of sorts who try to make a difference in the world and I hope that this small orchestration, small but I hope important orchestration on our part, is a step in the right direction. As Inakshi said, it's a really sobering time in the world, I'm locked down in my home in Newton, Massachusetts and watching my other home in Delhi, it's very sobering, it's very, very sobering. Just can't imagine what's going on and I see the data that say that cases in Mumbai have exceeded the Wuhan peak and Delhi, unfortunately, is not too far behind.

I'm sure the rest of the South Asia is crumpled as well but without belaboring the obvious crisis we are in the middle of, both health an economic crisis, let me just turn to introduce our amazing panelists and a very big thank you to all of them for taking the trouble to join us for this hour and 15 minute event. I'm going to introduce them in the, very informally, if I'm allowed, just for interest of time, they are all much more eminent than am I and don't need any belabored introductions but I'll just say a word or two about them in the order in which they are going to speak to set up the conversation that'll then follow.

First after me will be Dr. Gagandeep Kang, who is the Vice Chair of CEPI, it's an acronym, Coalition of, I hope I get this right, Coalition for Epidemic Preparedness Innovations, something to that effect, which is an organization that is dedicated to funding research on vaccines. She is of course a major researcher in India on enteric infections as she likes to say as others like to say it's all in the gut as it were, and has particularly demonstrated that these infections have lasting effects particularly if they happen to inflect kids. She is a recipient of many awards, including the Infosys prize in Life Sciences. It's a great pleasure to have her and she's going to talk about the science, what we know and what we don't know and I'm sure she'll speak to us in somewhat intuitive

terms for those of us who are not life scientists. She'd be followed by my good friend David Bloom, exemplary economist at Harvard T.H. Chan School of Public Health, and frankly a friend to me and a mentor if you'd allow me to call him that over the decades. He is an astute observer of India, Bangalore is his second home pretty much, and what's most relevant about David's encyclopedic work on demographic and public health is the fact that he happens to have studied vaccines for a very long time. He's going to talk about the broader social and economic ramifications of not having adequate vaccination in societies. So, once we have the possibilities of science established from Gagandeep and the economic importance from David, Umang Vohra who is the Managing Director & Global Chief Executive Officer, Cipla Ltd, I have requested him to share with us, even though Cipla doesn't work in vaccines per se, it's one of the leading firms in the world on ensuring access to high quality, low cost medication to the developing populations of the world and more. So, he's going to pick up on Gagandeep's and then David's comments about the possibilities of science and talk about the role that the private sector can play and in particular emphasize some of the things may get in the way of the private sectors playing these roles.

So, with that introduction to the panelists, I will say a few words. I am an applied maths person, not really a vaccine scientist or a life scientist, and I've worked at the Harvard Business School for the last 25 years and my interest is in understanding how analytics and analytical economics in particular can be used to structure things so that good things happen in the world, in particular the developing world which is a 100 percent of my attention. So, to move back into the topic here, I guess it would be help to know, it may be obvious to some people to others it may not be, that the big problem with vaccines was that going back two decades or even more than that, there were actually inadequate economic incentives for pharmaceutical companies to develop vaccines and the reason was that most people in the world who needed the vaccines, which is everybody, just didn't have the money to pay for them.

So, you had big pharma on one side and organized science on one side primarily in the rich countries in the world, not essentially, and this would overstate it a bit, but not by much, essentially seceding from vaccine space gradually over time, and what that meant was that even though the possibilities of science were alive and well, the economic conditions were not in place and nobody was focused on this to get the science into the product and then get them disseminated to the public. So, not only there was a problem in terms of getting new vaccines developed, it was even a problem in the sense that there were lots of vaccines, yellow fever is the one that comes to mind, that were available in the rich world but it would take 10 to 15 years for them to slowly disseminate it into the poor countries, often triggered by a catastrophe of some sort. Into this stepped many well-meaning philanthropists and forward looking sovereigns, thinking about the Scandinavian countries the UK, France, places like that and Mr. Gates.

So this was one of the first project of what became of course now the Gates Foundation, the Bill and Melinda Gates Foundation taking on this idea, and famously Bill Gates said that to run something like Gavi, that's an acronym for Global Alliance for Vaccines and Immunization, that was the original acronym, famously Gates thought that Gavi could be run with five guys and a spreadsheet, should be able to do the analytics to make sure that there were enough incentives were in place for science to be unlocked, for people to be willing to receive catalytic doses of money and the private sectors they could develop the vaccines and then they would end up getting used. Gavi of course is a 300-person virtual alliance of sorts running out of Geneva in New York, run by my colleague and friends at Berkeley, it's an extraordinary organization and I think of it as the entity that waits for vaccines to be developed and then make sure that the incentives are in place for governments and private sector actors and non-profits to take the vaccines and deploy them. Sort of a parallel organization is Cepi, which Gagandeep will talk about, she is the Vice Chair of Cepi currently, which is also sort of funded by many of the same people, same organizations and sovereigns. But its function is more to fund research on vaccines, so think of loosely and David and Gagandeep can correct me if I misstate this, but I think of it as, in American parlance, it would be a pitcher and the catcher concept for those who are joining us from the north America or a bowler or a batter in cricket terms, bowler and batsman I should say in cricket terms, but the idea is Cepi funds the research for the vaccines and once the vaccines are available then Gavi puts the incentive in place to get them out there.

I think what I learned most from a deep dive into Gavi was that it really pays, that there is as much a role for scientific creativity as for organizational entrepreneurship creativity because until you can have the intermediating organizations, so if you think of vaccine development and science on one side as the supply side and you think of the demand side being you and I who need the vaccines and poorer people all around the world, less fortunates who need the vaccines, a lot of stuff has to happen in between for the conditions to science to come to market. What I also found really fascinating about Gavi and other things that there are so many, simple to state difficult to put into place, economic ideas, among them the ones that I like really, I'll just highlight two

to illustrate my point. The idea of vaccine bonds, which are bonds that are floated in the global capital markets, either euro bond market, or sukuk bonds in the Middle East, or bond directed to Japanese pension funds, they are financial securities designed to ensure that when sovereigns make commitments to donate money those commitments are made over very long time horizons and are often subject to politics issues in the donor country, but to translate them into something very credible for people like Umang who are charged with their shareholder responsibilities in private entities, it's important to have more credible finance. And that's where the global capital markets come in to say yes we see the promise, we think that this can be transformed into a short run credible promise that will reassure manufacturers to invest in the capacity to make the vaccines so we have it in the first place. So, vaccine bonds are a good idea but the more underlining point I'm trying to make is that there has to be an engineer or economic architect that is thinking about these things in order for this stuff to happen.

My roommate, classmate Michael Kremer is one of the people who came up with the idea of advanced marked commitments, which are another way of making a credible promise from governments to manufacturers, saying that we assure you that we will top up the amount that poor people may not be able to pay you if you commit to producing and selling this much dosage of vaccine. So, think of it as loosely as an alternative to impact mechanism for reassuring people of doing things so that they have the incentives to do it. So, I'm going to stop at that. So, just think, for the non-specialists in the audience, which I think as most of us, and I'm included in that bunch, think of the science being developed by amazing scientists, think of the users you and I and less fortunate people, and think about the organizational creativity that has to happen between and now we are going to go, sort of in orders, science then talk about the intermediating mechanisms and the private sector to see how this can play out. So, without further ado, let me invite Gagandeep Kang to please unmute herself and share some of the science with us in Cepi please?

**Gagandeep Kang:** Sure, so thank you very much Tarun for the introduction and for setting the state. And, really to talk about the pandemic, I'm going back to an epidemic, an epidemic as Ebola. So, if you look at what happened about six years ago in West Africa, you had the Ebola outbreak which affected about 30,000 people, we have another one ongoing at the moment but that was the one that kind of brought Ebola to the fore. So, it affected just 30,000 people but it was something that everybody in the world got to know about. It was estimated that of those 30,000 people, about 30 percent died, so about 10,000 people. It cost about four billion dollars in direct costs but the world bank has estimated that it cost about 54 billion dollars in total costs. So, the funny thing about Ebola and that outbreak was that there was actually an Ebola vaccine, the vaccine had been made, it had been sitting in somebody's freezer in Canada for a while and there was no interest in an Ebola vaccine even though the disease had been known since 1976 and the vaccine was never developed. When Ebola came around then suddenly everybody started jumping up and down and saying oh gosh the deadly disease might spread to many parts of the world, let's make a vaccine, and they looked around and found multiple vaccine candidates and started work on the vaccine. But by the time they actually got their act together and started to test the vaccine, it was towards the end of the epidemic, many things had happened in terms of setting up Ebola hospitals etc. and getting WHO and getting partners on board and finally the vaccine started to be tested more than six months after Ebola had been declared a public health emergency of international concern.

What happened with that vaccine was, you didn't wind up with enough cases of Ebola to be able to say whether the vaccine truly worked or not. So, it wasn't possible to take that vaccine at that time all the way to licentia. Now while Ebola was happening, people started to think about why are we in a situation when there was a vaccine available, why has it taken us so long to get to this point? And that's how Cepi was formed, Cepi was actually was going to be pandemic preparedness and then it was decided that when there is a pandemic then everybody in this world is going to be interested in making vaccines, however, if there are epidemics and if those epidemics happen in low and middle income countries, then nobody is going to be interested in vaccines. And, it's important to recognize that over the last 30 years, with consolidation and shutting down and buyouts, we've actually wound up with very few multinational companies wanting to make vaccines, and the ones that do want to make vaccines for a developed country market where they can sell lots and lots of doses every year. Nobody wants to make an Ebola vaccine when Ebola is going to affect in its largest outbreak, 30,000 people, you don't make things only if you need 100,000 doses. So, in response to all of this, a bunch of people, the Wellcome Trust, the Bill and Melinda Gates Foundation, the World Economic Forum, the Government of Norway, and the Department of Biotechnology from India decided to get together and they were the five founder members of the Coalition for Epidemic Preparedness Innovations. The idea of Cepi was can we identify what is going to cause outbreaks and start work to develop vaccines on those targets as well as can we think about platforms that will allow us to develop vaccines really quickly. So, if we are going to have a disease

X, a disease that nobody knows about currently that is going to emerge at some unknown time and some unknown location, and affect an unknown number of people, can we really make a vaccine quickly?

So, Cepi was started about three years ago and funded its first platform technologies program targeting disease X last year, and when we had the pandemic starting in January. On January 10th, we got the sequences of SARS Coronavirus II by the end of January, Cepi had funded four programs to make vaccines, taking all of the programs that it had disease X and converting them into programs for this new target. One of the things that is most interesting from a scientific perspective about this pandemic is how much science is being used. In the last 20 years, we have had an explosion of technologies that allow us to make new vaccines, that allow us to interrogate the immune system in ways that we've never done before, and we are using everyone of those technologies to address SARS-CoV-2. There are currently about 230 programs, maybe a little more than that, every time I look the number goes up that are looking at making vaccines. There are about a 130 that are reasonably advanced and we have 10 vaccines that are already in clinical trials and these started out being in clinical trials made mostly in the wealthy countries, in Germany, in the UK, in the US but I just heard that Astrazeneca has signed up Brazil and that will be the first low and middle income country that will be participation in a trial of the Astrazeneca vaccine.

Now, why vaccines? Obviously, it's better to be able to prevent a disease than to treat it and this is something everybody is waiting for and there are a lot of naysayers who say do we know we are going to be able to make a vaccine? You know this is a completely new virus, we don't know enough about it but I think the data that are emerging from the clinical trials as well as the studies we are seeing in experimental animals are telling us that a vaccine is feasible. We've had vaccines that are quite strongly immunogenic that allow people to make not just antibodies that you can measure in the form of binding to proteins but also antibodies that are functional, that allow for neutralization of the virus that usually means for most viruses that we are going to have a vaccine that is going to work. We also have monkey studies that have been done with at least two of the vaccines and in one study we were able to completely prevent infection and the other study we were able to prevent disease. These are very reassuring data that tell us that if we can get the right kind of vaccine, there is a good chance that these vaccines will succeed.

I'd like to move from that, which is the global picture to what's happening in India and in India I think one of the things people need to recognize, it's known in India but perhaps not in other parts of the world that India actually makes more doses of vaccine than any other country in the world. We are the biggest supplier to Gavi, which Tarun mentioned a little while ago, and the companies, three companies that work out of India are major supplies, they can make hundreds of millions of doses every year. These are Serum Institute of India, Bharat Biotech, Bio E, these companies have started on, each of them has started on multiple vaccine candidates and there are smaller companies in the world that are looking to make new vaccines. So, there are more than a dozen programs making vaccines in India, we are a little behind of what has been done in the West, but we are anticipating that we will be in clinical studies in Q 3 of 2020. So that is one way of thinking about it, will our own vaccine candidates actually result in vaccines? The other part of it is something that is in the news and will be in the news is India's manufacturing capacity, because we have the capacity to make so much vaccines depending on which platforms are successful, if you need to make hundreds of millions of doses of vaccines, you need to be thinking about coming to India if that platform exists in India. So, multinational companies are having discussions with Indian manufacturers to see whether their vaccines can be made here. There's also, even if we don't manufacture, we have a lot of fill finish capacity so if it was required then we could use some of our finishing lines to make vaccines for the world. There are of course lots of issues, there's regulatory issue, there's a global shortage of glass, there's a global shortage of syringes, 230 candidates mean that three of four will succeed, so have a long way to go before we get to vaccines but I think we are on the right track, we are moving as fast possible and faster than I thought was possible six months ago. Thank you, Tarun and I'll come back in later.

**Tarun Khanna:** Thank you so much. Let me just ask you one question before we go to David, Gagandeep. It's coming through on the scrolling functions, to novices like me it's kind of sobering to, that note of optimism is wonderful, because it's sobering to realize that some viruses like the HIV we have not been able to create a vaccine and after many decades and that seems to be related to the question that's coming through a few times about the mutation of SARS-CoV-2. Can you talk about differences in the way viruses mutate and how that may or may not get in the way of vaccines or cocktails drugs that ultimately control infections and so on. Very briefly if you don't mind?

**Gagandeep Kang:** Sure, so SARS-CoV-2 is an RNA virus. RNA viruses mutate more than DNA viruses do but you have to think about why a virus mutates. A virus mutates to get away from the immune system and

that's the response that will require us to have a new vaccine. There are actually very few RNA viruses for which we have made vaccines where the immune pressure has been so much that it has required us to change the vaccine. We've never made a vaccine for HIV, we have to change vaccines for influenza, but even there who are infected with an old influenza strain, you might still have partial protection. In case of this new virus, there is no pressure on it to mutate in the areas that are responsible for the entry of the virus, that are responsible for neutralization. So many of the changes the strains that we are seeing currently are important for tracking transmission but are not yet currently in as much as will require us to change vaccine strains. So, I think for a few years, we are on pretty good ground.

**Tarun Khanna:** Great, thank you very much. Let me turn to David. David Bloom.

**David Bloom:** Thanks Tarun and hi everyone and good morning, good afternoon, good evening, depending on what times you are in. So far in this session, we have heard about two bonafide institutional innovations Gavi and Cepi. As we heard from Tarun, Gavi is an innovative mechanism for mobilizing funds and channeling them into productive uses that involve the promotion of vaccine access and coverage in low-income settings. And Gagandeep described Cepi as an innovative mechanism for mobilizing funds and channeling them into development of vaccines for emerging communicable diseases. What I'd like to do now is to add to the discussion by focusing on another innovation, a conceptual innovation having to do with the way that we assess and value vaccinations. This is also an innovation that supports the efforts of Gavi, it supports the efforts of Cepi, it supports the efforts of developing country vaccine manufacturers, also vaccine developing divisions and big pharma. What I'd like to do is structure my remarks, I'll make three points, first, I'm going to argue that vaccines are generally undervalued and often appreciably so, second, I'm going to argue that undervaluation, this undervaluation has done much to our individual and collective peril with respect to the optimal allocation of social resources, and third, I'm going to argue that the problem of undervaluation can be cemented, fortunately, by adopting a broader approach to help technology assessment.

Essentially, what we need to do is we need to shift from a narrow health-centric perspective to a more expansive societal perspective. And, then I would like to say a few things at the very end about Covid and what Covid means for some of these points. Now, very briefly, when a health economist assesses vaccines for purposes of public recommendation and reimbursement decisions, they typically and traditionally focus on two items, first, the health gains associated directly and sometimes indirectly with the use of the vaccine, and second, reductions in medical care costs that are due to having fewer infections. They then calculate what, in health economics, we call a cost-effectiveness ratio that's basically the ratio of the health gains to the cost of the immunizing agent that is its administration, that cost being led of avoiding medical care costs and if the resulting cost effectiveness ratio exceeds some pre specified threshold, the vaccine gets a thumbs up with respect to with respect to recommendations and reimbursement decisions. So, it's very cost effective in the sense that per dollar spent it produces a lot of health, is basically the idea. Now, I acknowledge that morbidity and mortality reductions, in other words health improvements, and also in medical care cost savings are indisputably benefits of vaccination, and I'm not arguing that the cost-effective analysis that are routinely conducted throughout the world in connection with these recommendation and reimbursement decisions, I'm not arguing that they're inherently flawed. In fact I think that they answer very well a key question that stays by ministries of health and departments of health and namely that how to prioritize the use of a fixed health sector budget to maximize health.

My point is simply that the dominant focus of these health centric cost-effectiveness analysis is limited to a very narrow portion of the total benefits enjoyed by society from a vaccine. The analysis, the cost effective analysis, the narrow health-centric cost effective analysis lede out a long list of economic and social benefits, they also lede out some health benefits, I'm going to speak about those briefly as well. And neglecting all these sources of health, economic, and social benefits skewed decisions about the allocation of social resources in a socially optimal direction, in other words, it makes it socially sub optimal and my point here is basically that too little money is getting allocated for the development, manufacture and the delivery of vaccines.

I hope you all won't mistake this for a bland assertion, I think it's hard to believe now here in June, but the World Bank and Cepi were struggling mildly as recently as March and April to raise just two billion dollars in support of R&D on eight to ten Covid vaccine candidates, and many of the arguments and points that I'm going to discuss were used in support of their fundraising efforts. Let me just quickly share a small subset in the ways in which health economists around the world give short shrift to the full societal benefits of using vaccines. So, I'm going to say a few words first about the health benefits, then something about the economic benefits that are neglected, and then something about the social benefits.

So, in terms of the health benefits associated with vaccines, traditional health-centric cost effectiveness analysis commonly neglect vaccine cost reductions at the pace of which anti-microbial resistance develops and that's due to both resistance developing both slower pace because of vaccines prevention of resistant infections and also to reductions in both the appropriate and inappropriate consumption of antibiotics. Now, antimicrobial resistance is a whole other dark cloud hanging over humanity, it's as significant a dark cloud as Covid-19 at the moment, and I would say that the value of vaccines and addressing that threat needs proper consideration and measurement. In terms of neglected health benefits traditional cost-effectiveness analysis also give short shrift to preservation of the micro biome associated with reduced consumption of antibiotics, this is something that Gagandeep heard me a number of years ago and I think it's almost starting to come to the fore again. People are realizing, I think as you put it Gagandeep the gut is where it's at, and I think it's true and antibiotics undermine the gut and the health effects of good gut health.

Traditional cost-effective analysis also neglect reductions in health conditions that are comorbid with the conditions that are directly caused by pathogens that's the target for a vaccine and cost-effectiveness analysis even neglect heard effects as well in many cases. So, those are some of the neglected health benefits of vaccines, which I think is inexcusable on the part of the health community to have neglected these benefits for so long. But let me go on and make a couple of other points here, and the next point is that routine health centric cost-effectiveness analysis also typically neglect a whole slew of vaccines' economic benefits. I'm just mentioning a couple, for one they neglect higher returns to education to the healthier kids having an improved school attendance, higher educational attainment and better cognitive function and focus. We think of education as having a very special place among instruments of economic growth and development and it's also inexcusable that we've neglected the benefits that vaccination brings to, and the enhancement it gives to the return of investments in education. Health economic cost-effectiveness analysis also neglect increased labor force participation, increase hours work, increases in productivity and adult earnings, I'm talking here about the additional income people generate when they are healthy enough to work and also don't have to care for ailing family members. And that's not to mention the increased value of non-market time in various productivity activities involving family and community which is especially important among the elderly. We tend to basically discount the value the lives of older people because they don't work, but actually older people, if you look timely studies older people are engaged in a great many productive non-market activities and we should be joining them as well and if you do, it enhances the value of vaccinations considerably for elderly vaccination.

Finally, a traditional health-centric cost effectiveness analysis often lede out important social benefits, here I will draw very quickly everyone's attention to the improvements in social equity that typically result from the fact that benefits of vaccines also accrue disproportionately to poor people who live under crowded conditions and also to disadvantaged racial and ethnic minorities and vulnerable groups like women and children who maybe just simply lack access to healthcare. So, that's my first point about the undervaluation of vaccines and let me turn quickly now to the second point having to do with the fact that undervaluation can lead to an inefficient allocation of social resources. And, I'll make this quick because I'm basically trying to convey the idea that taking account of full societal benefits is consequential not just in theory, it's not just an interesting idea from some research university, it's also an important idea in practice as well. So suppose, let's do a thought experiment, suppose a public authority decides that a vaccine doesn't create enough value to merit investment, happens every day throughout the world, but let's also suppose that this authority considered only a narrow swath of the vaccine's full societal benefits. In my point of view, we can't be sure that the negative decision is a good one, perhaps it's the case that the vaccine would have demonstrated high value for money if the authority focused on the full benefits and what I can tell you is that with few exceptions, studies on the full societal value of vaccination point to rates of return that vary from attractive to super attractive to absolutely eye-popping, and I'm speaking here of rates of return that easily surpass the return on investment in basic education, even basic education for girls, which operates as I alluded to a moment ago, kind of an exalted place in most of our minds and are treatises as an instrument of economic growth and development.

I'm speaking here of benefit cost ratios that flip from less than one, which is basically a thumbs down on making the investment to less than one now benefit conceptualizations to decisively more than one under appropriately broader frameworks and I'm also speaking on investment numbers that sometimes surpass 100 percent okay, and just to put that in context that's nearly two orders of magnitude higher with the current yield on US treasury bills. So, yes, vaccines are costly to do but what we are increasingly finding conceptually and supported almost uniformly by empirical evidence is that they are far more costly, vaccines are far more costly not to do. I know here as well that the arguments that I'm offering in support of the need to measure full societal benefits are not limited to health technology assessment of vaccines, they apply quite generally to all health interventions, so that would include medical devices, pharmaceutical drugs, health system strengthening and reform as well.

The point here, and it's kind of a nuanced point, the point is that vaccines are specifically disadvantaged by the now health perspective that has dominated the conduct of health technology assessment for decades and that's a disadvantage that reflects the time horizon from joining the benefits of avoiding childhood infectious diseases mainly, that's the primary target of most vaccines and it tends to be much longer than for the treatment and prevention of diseases among adults or older people for example. The disadvantage of vaccines also reflects the relatively large populations that vaccines can benefit the fact that vaccination against infectious diseases tends to have larger benefits than interventions against non-communicable diseases, heart disease, chronic respiratory disease, cancer, diabetes, mental health problems as well. So, to wrap the second point up, the good news I would say is that all the benefits I discussed, all these additional health benefits, economic and social benefits, and at least in principle they can be conceptualized, they can be quantified, they can be monetized and they can be coherently and consistently analyzed in the form of a benefit cost analysis or rate of return analysis that's so familiar to all the business community.

Let me now just move into kind of a final set of comments I wanted to make because I think it's clear the world is struggling through Covid, let me just offer a few remarks on the implications of the pandemic. The structure and operations of immunization echo systems and also for global understanding of the value of vaccination. Let me just distinguish between the short run and long run implications of the pandemic, so in short run, Covid-19 has interrupted many routine immunization programs okay and that threatens to elevate rates of vaccine preventable diseases, and also they are physical, they are mental, and they are cognitive healths equal our across the life cycle.

So just as one example, just last month the WHO, UNICEF, and Gavi reported that the pandemic is forcing 80 million children to at least temporarily forego vaccine protection against one and more disease-causing pathogens, that 80 million corresponds to roughly 60 percent of world's annual birth cohort and I would note that the WHO also expressed concerns about Covid-19 caused interruptions in polio eradication efforts, and they also called out the possibility of a worldwide surge in measles cases, which would be most regrettable. Notwithstanding these significant short-run speed bumps, Covid-19 could, I would say over a longer horizon, actually mark a sea change in global appreciation towards value of vaccination, and that's a speculation on my part and it's a speculation that is underlined by the notion that the range and the intensity of the losses that we are all suffering during the current pandemic are going to have the beneficial effect of highlighting the gains to be had from preventing Covid-19 in particular, and infectious diseases more generally. So, along those lines I would say that Covid-19 is going to raise awareness of and I think will help lay to rest a long list of scientific, policy and economic disputes about the value of vaccination. So, what is on this list?

So this list includes disputes about indirect protection of vaccination involving the promotion of herd protection. Well, herd protection has now become a household term okay and I think everyone is starting to assimilate the idea and I think it's going to be increasingly reflected in the analysis that we do. The list of areas where awareness is going to be raised of the value of vaccination also includes the reduction in the risk of nosocomial infection during inpatient stays. So many people are not going in to hospitals and clinics if you are contracting Covid, so you're just suffering at home when you're in need of medical care. One of the values of vaccines but it keeps people on a possible, keeps them from contracting nosocomial infections and basically or drug resistant infections which they transmit to others. I'm talking here also about the disputes about the economic benefits of vaccination associated with increased labor supply, hours work productivity and income. We're talking about trillions of dollars of economic losses here that vaccine for Covid could have actually promoted. And, I would just call attention here to the fact that several years ago there was a lot of research on SARS, which is also a coronavirus and we were in a pattern of basically panicked neglect at that point, so that was a period of panic, a lot of research was done okay but as soon as SARS evaded we went into a period of neglect and during that period of neglect we basically gave short shrift to further research, and we would be much better off today had we continued that research.

**Tarun Khanna:** David, I need to interrupt. We need to move on to Umang also and then have some time to discuss, so if you could wind down, it would be good actually.

**David Bloom:** Oh, okay. I'll just, the basic point I'm trying to make here is that I understand that the Covid-19 pandemic is a terrible calamity but if it has any silver lining, I think it may prove to be the way in which Covid-19 helps us paves a new path for vaccines that is going to enable us to make, to elevate the condition of human health and wellbeing in the future. I'll stop there and sorry for going on so long Tarun.

**Tarun Khanna:** No no, it's a super important point and I had a couple of follow-up questions but I'm going to hold back in the interest of time. We'll go to Umang and then we'll move into our discussion. Umang, if you don't mind, please?

**Umang Vohra:** Sure, certainly. So, Tarun thank you for having me on this panel and I represent Cipla which has years and years of experience in treating HIV, antimicrobial resistance, working with, you know, we also sell vaccines, but we don't make vaccines. And, so some of the comments that I'm going to make today, and essentially three of them are really around what does it take to move from the hope that the vaccine offers to a point where vaccination delivers lasting cure, vaccination or other treatments deliver lasting cure. So, let's start with that, I think I'm going to take on lessons that we've picked up through this in our practice in Asia, in Africa, maybe other parts of the world, but I'm also going to argue that I think, if we begin to look at this, this is perhaps the first or maybe one of the few times in the world and at this scale of eight billion people, we are going to have an adult vaccination program. Keep that in mind you know, child immunization is different, adult vaccination is different and in some way the pharmaceutical industry has dealt with this before when it tried to find cures for diseases like HIV etc.

So, I'm going to try to talk a little about that but I would just like to say these are our learnings, my learnings, and we are humbled every year with something new that we pick up and how we need to treat models to make sure that care reaches where it needs to. So, I'm essentially going to talk about three things, I do want to talk right at the beginning about this balance between equitable access and in some way vaccine nationalism and I think there's a way out there and again it's out of the lessons that we've had working in some of these markets. The second thing I do want to talk about is availability and affordability and that necessarily does not mean access and what happens when you bring access into the equation. And third thing that I would always advocate is that there has to be a Plan B, because I think the, I'm as hopeful as Dr. Kang and David are about having the vaccine but it's going to be four years, five years before when everyone gets vaccinated and the world still has to live with this disease till then and we don't even know if there's immunity that would be guaranteed for a very long period of time with each vaccine.

So, let me start with the first and this is really about achieving this balance between equitable access and vaccine nationalism, and I think this is an important point and I think it's an important for most governments to consider because I think very often the emerging side of the world and the developed side of the world are in opposite sides of this equation. I think the emerging side of the world always thinks about the developed side of the world arguing for vaccine nationalism, actually it should be the other way around. I think it's the emerging side of the world that needs to argue for vaccine nationalism, the more the emerging side of the world argues for its own sources of medicines, its own sources of vaccines, the faster it is going to be easier to eradicate this. So, I think if you were, just broadly put this, other than India, there's no other big emerging market and of course China is coming in as well but there is no other big emerging market that has enormous amounts of vaccine production. And I think that's something for everyone to think about, not only is it for vaccines, even for pharmaceutical drugs, we see very little self-sufficiency across the world to do this. I'm going to argue that the government's had a very, very large role to play in this. I think there are models today around the world, whether it is for HIV, whether it is for liver diseases, where multinational organizations are willing to share technology if there are local players who can take that forward and begin to produce, mass produce in their country. Like I think the scene that happened now for viread, abacavir, the thing that happened for several other drugs in HIV and I think the model exists but the model has to be taken forward by the emerging side of the world and manufacturing is a very big role for that. So, I'm going to say that most governments, in most countries need to be a lot more vocal for being local or being global, as in regionally cooperating. Iso I think if you go vocal for local, we tend to see a huge amount, a huge amount of congregation between governments that set up manufacturing in their countries, vis a vis, finding an ultimate cure for the disease that trouble them. So for example, take Uganda, take South Africa, they were seized with this Aids epidemic, they set up manufacturing to deal with it and there's enough amount of government skin in the game to tackle the situation. So, I'm going to say that it's almost going to become a necessary condition if vaccines have to take center stage as David was arguing, if the amount of money and research in vaccines needs to go up, I think the biggest role that needs to be played is by governments and sadly today a lot of governments rely on global funding, which is my next point to take this forward.

So, I want to talk about global funding because I think we are at a very weird sort of a place in history and again we're taking panelists from some of the other diseases that talk about the benefits of global funding but we are at a very weird, we've seen, we're at a place where globalization is retreating, we're at a stage where the WHO funding is in question and we have to think about this and say if HIV was eliminated a lot of that have to do with Pep pharma and how the US government basically bankrolled along with this funding under this

who while seam of threat anywhere is a threat everywhere, to the disease. We're at pretty much at the same stage here, except that I think the large funder governments are beginning to have thoughts about whether they, and how much they want to contribute to this overall cost. So, Tarun you introduced the session by talking about vaccine bonds, Dr. Kang spoke about this as well in terms of being reliable but I'm going to say that if there's no viable funding mechanism, I think it's almost going to be impossible to tackle this because no private player who has responsibilities to the shareholders or any other, remember it's not just a big pharma companies that have to do these, these are axillary units as well. The whole ecosystem for vaccine delivery, you know whole ecosystem for fundamentally delivering care has to be very different.

So, here's some trivia, we find that the cost of delivery and just the medicine cost of delivery of HIV and other drugs to some of the countries in the world is 25 percent of their component, it's just a freight cost of moving product from a manufacturing site to a country where it needs to be used. That's what we mean when we say that I think that if countries begin to become more vocal for local manufacturing, it is going to make a difference to the progression of the disease. So, I'm going to talk a little about vaccine strategy as well, I think we have, there are two sides of the world solving for different things, I think there is one side of the world which is solving for speed, which is in a way there are and the people who are discovering this, if you really go back to 2009 epidemic, the Swine Flu epidemic, it's pretty much the same names coming up Novartis has signed up, Astrazeneca is there, GSK is there, there's no difference in the quality of the names that are coming up. But you have to ask what level of vaccination success happened with respect to swine flu in the developed market versus eleven years later in the developing markets of the world, these two are very different in terms of overall outcomes. And, I think the reason is that this side of the world, which is the merging side of the world needs to actively sign up for access and I'm going to talk about that a little later but I think the outcomes are very different, the western side of the world has the benefit of concentration, has the benefit of well-set up healthcare systems, but it's really, the story starts from availability of the vaccine to mass vaccination or to mass cure as you would talk about other diseases only when the entire row is lines.

So, I think availability and that brings me to my best point, availability and affordability are very important and there's no doubt about that. I think the hope starts once the vaccine's cure is available. But I'm going to argue that access is not equal solely to availability and affordability and we've learned this the hard way, RDA suggests that the cost of the vaccine is only 50 percent, the cost of cure is only 50 percent of the total existing cost. Even if you have drug delivered in Uganda, even if you have drug delivered in South Africa, or if you have drug delivered in Vietnam, 50 percent of the rest of the cost is just the total cost to bring this drug to market and other private players need to have. So, funding we spoke about is very important and even then the outcomes are very different. So, in South Africa, we have four million out of the seven million people currently using antiretroviral drugs for HIV, you may say HIV is life threatening, why would anyone not naturally go there and I think that's the complication of trying to get a global effort which starts from development all the way to commercialization. So I would advocate that there has to be a solid private public government participation over here, private parties take the lead when funding models are very clear, when the government guarantee is off stakes government has stake in manufacturing.

I think the other thing we've learned which is also fairly significant within this overall availability plus affordability does not equal access thing is that trying to bring a vaccine or cure to people versus bringing people to take the cure, I think it's always the former. So fundamentally the role of communities is exceedingly important in any kind of mass cure or mass vaccination program and there's this saying that you know the Aids activists have developed over a period of time, and which is whatever is done without communities is done against communities. That's something to think about, the role of the community in doing this, one great example that we do at Cipla is we have this pick up point for even delivering HIV medicine, which is right in the center of communities. It's not at hospitals, it's not at mass vaccination centers elsewhere. I think the experience of polio in India and how we have been able to eradicate it is pretty much the same. So, I would just say that you know this whole thing of the community, the government, the pharmaceutical manufacturers, that's 50 percent of the effort over and above the vaccine and its cure.

The last thing I want to talk about today is this whole thing about Plan B. I hope the vaccines work but realistically we've had HIV and we've had no vaccine for it, we've had dengue and we've had a vaccine just last year for it if my data is correct. There's a lot of hope and I hope it works but the world has to live with supportive care till everyone gets vaccinated and I think that's the very, very important point that we need to think about that for three years of four years people will still have to be treated till they get a vaccine shot and we have no clarity today on what levels of immunity the vaccine provides over a longer period of time, it could be for a year, it could be three years, it could be booster doses and so what we are tabulating in terms of available capacity, you know the first set of people get vaccinated by the time the second come, the first need another

shot. There is going to be need for higher levels of capacity, so I'm going to argue about having equal amounts of money if not more for the pharmaceutical industry to think of antiviral drugs, to think of repurposed medicines that could cure this because no matter what we say about a vaccine and I'm very supportive of it, I think true cure counts when antiviral therapy is available across and you know oral vaccine which you can take any now or then versus something that's administered once and while and gives you immunity is always another good, solid option for Plan B. So, I'm going to stop there Tarun, I think the vaccine offers a huge amount of hope to the world and the translation of that hope to reality is unfortunately something that's accomplished with the enterprises by the businesses and depends tremendously on funding, tremendously on government off take, guaranteed government off take, depends on government's skin in the game because of being vocal for their local needs in terms of manufacturing. It's about the role of communities and our experience with that and also it's about desegregation of the overall vaccine chain or the overall pharmaceutical chain from what happens in the West to the other sides of the world. So, I'll stop with that, I'm happy to take Q&A and like everyone else I'm hoping that we get through this very quickly and wishing every healthcare worker out there a deep sense of gratitude.

**Tarun Khanna:** Thank you Umang, thank you David, thank you Gagandeep for those wonderful comments. We have 15 minutes left for the webinar, there's a proposal that we extend by another five. Is that okay with the panelists to go for 20, instead of 15?

**Umang Vohra:** I'm fine with it.

**Tarun Khanna:** Okay, so that's what we'll do. I know about, I counted 86 questions scrolling which are themselves aggregation of questions. So I'm going to exercise my subjective authority and simply pick things that seem to be really generally of interest to set groups of people. Let's go back to the science for a second, Gagandeep can you say a word about this last point that Umang mentioned, which is obviously it is not only about the vaccine, we should be thinking about diagnostics, we should be thinking about therapeutics, we should be thinking about vaccines, I don't want to put you on the spot but can you say a little bit about how to think about those that ensemble of things as opposed to only the vaccines?

**Gagandeep Kang:** So, in terms of controlling the pandemic, there's a role for diagnostics, a role for drugs, a role for vaccines, all of them are critical components and if we think back to the first SARS, we actually solved that problem without the drugs and vaccines. We solved it by using old public health techniques basically making sure that there was no transmission of infection, and that's what we are doing with this pandemic as well. We are making sure that we have social distancing, we wear masks, we decrease transmission and when people get sick we offer them supportive therapy. So, all of these have a role to play. Something as simple in looking after patients, the idea that lungs are better aerated if the patient is in a prone position, we did not know that until we understood what was happening with this particular virus. So there is, drugs and vaccines and diagnostics are tools but we have other tools as well. In terms of whether one is better than the other, obviously I think prevention is better than cure but there is a role for both.

Vaccines have been successful for many things, unsuccessful for others, antivirals are actually really, really challenging, we don't have an antiviral for measles at the moment but we do have vaccines. We have drugs, antivirals that's really good for HIV but we don't have an HIV vaccine, so it's not about playing one off the other, it's how many tools can you have in your toolbox to address this problem.

**David Bloom:** Can I just add one comment?

**Tarun Khanna:** Yes David, please.

**David Bloom:** So, yes vaccines, yes diagnostics, yes treatments, I would also, I think one sort of glaring deficiency in this area is the absence of good data, reliable data on surveillance. What we see throughout the world are these graphs and these models, so there are huge differences in the estimates and projections of Covid coming from different models. Even in the same model from day to day is changing so dramatically, you know bouncing up and down, it's moving like a pinball, which is very unfortunate. And, I think the problem is that the models are basically fine structurally, we're feeding in unreliable data to them because it's coming from highly selective samples, we need to focus much more on representative samples and collect data for dose, including testing data. It's easy, inexpensive, well-established approach to doing this and I would like to see more of it throughout the world.

**Tarun Khanna:** And I should mention David has been very instrumental in putting this into play in the state of Massachusetts and elsewhere in the US. So, thank you for reminding us of the role of data and informed decision making not just in the actual scientific process but more in structuring the entire the societal value chain that Umang was also mentioning. Let me ask a slightly different question which connects to things that both David and Umang alluded to which has to do intellectual property rights. I remember reading very recently, I think it was Costa Rica that made a submission to the WHO saying that there should be global patent pools in some way and in a sense, a way of saying that the IP is never going, a vaccine if it remerges it's going to emerge in China or the US most likely populistically, and then what happens after that? So just thinking ahead, but anyone in the panel want to comment on any aspect of intellectual property as this is a recurrent theme in the chat function. Gagandeep, you have your hand up so you go first.

**Gagandeep Kang:** Yeah, hi. So from Cepi one of the things that we did early, Cepi was set up with donor funding and the idea was equitable access and we've had discussions about IP right from the get go. If you are doing early stage funding of vaccine development, you are actually taking on a project that has a much lower probability of success than a later stage project, which is where MNCs are now coming in and buying up small biotechs. So how do you quantify risk? One of the things that Cepi thought about was step in rights that would go through the entire life cycle of the product. How do you create a structure that ensures that wherever the vaccine goes, it will always be an affordable, accessible vaccine and those kinds of agreements have been really very hard to negotiate and in fact it's one of the reasons why none of the MNCs really came into a Cepi project , it was mostly small biotechs.

**Umang Vohra:** Maybe Tarun, if I can go next. So, I think there's you know, honestly on this side I really think this was a big issue for the pharmaceutical industry, I can imagine it becoming a big issue for vaccines now but I think my experience over the last seven years is that it's not such a big issue anymore. And I think there are three things that have driven it, the first is the coming up of the industry in India etc. to provide quality products at affordable prices, the second is the willingness of multinational corporations to actually tie up and in some way either do an agreement that allows these people to make for a range of countries or in some forms compulsory licensing time agreements which makes the drugs available or the cure available for people in the countries, and the third thing is the viable funding models, the intermediaries that can guarantee this kind of access for all the private players. I think if those three put right, I actually don't think intellectual property is coming in the way at least on the pharmaceutical side of the world anymore. Because any product is either license that's happening into the country or it's just a license to produce and manufacture like we have for remdesivir like we have so many other drugs. All life-saving treatments are actually, there's a model available.

**Tarun Khanna:** A question again for any of the panelists and Gagandeep you alluded to this in your opening comments and it was interesting that India was one of the signatories to Cepi or one of the original founders of Cepi, but my sense is that and please correct me if I'm wrong that historically there has been an inadequate, and both David and Umang spoke about this might be an inflection point for appreciation of science, but I think India and the developing countries have put in less into the relevant science than arguably they should have, that's probably an indisputable point. But practically speaking, is there a way that you can see developing countries like India or Brazil or places like that playing a greater role in the science that's needed to develop antiretrovirals or antivirals or vaccines or what have you? As opposed to the manufacturing point side as Umang and others have pointed out, we have lots of capacity.

**Gagandeep Kang:** I think one of the things that has changed a lot in the scientific world today is that we are no longer as far behind to the West as we used to be. Twenty years it would take you six months to get a reagent, you had to plan new experiments way in advance, now it's gotten to a stage where it's weeks and months rather than years. So, if there is a decision made that in terms of biology there is a target that we are going after, we have really strong science institutions that can do this. Now, why are companies not investing as much in R&D as in other parts of the world? Well it's really because Gavi and others are really shaving profit margins for Indian vaccine companies. You are making billions of doses but you're actually making very tiny amounts of money on your every dose of vaccine that you sell unlike the multinationals where the margins are much larger. So the ability to invest in R&D with industry is low. We also have now within the government the department of biotechnology, the department of science and technology that are willing to offer a lot more funding than was available. It's nothing like the scale that you could get from the European Commission or you could get in the US but it is significantly more than was there before. So, with this alignment of academia now being willing to work with the industry and government being willing to fund, I think we are going to see a lot more science and a lot more R&D with Indian industry in the future, certainly where biologicals are concerned.

**Umang Vohara:** Maybe, can I add to that Tarun? I agree with Dr. Kang, we're certainly not several years behind anymore as an industry. But there are some practical challenges as well, I think if you got to China's model and I'm not arguing whether that's the best model or not but you know just the sheer presence of an ecosystem that can attract talent to come and experiment, to come and learn and to be incentivized are very different. So, let me explain it, if you know a large portion of China's economic model actually started with a row of migration of their talent from San Francisco, and I'm talking about the technology model back to the country, back to their own mainland and they created this huge economy, they created this huge clusters of innovation to help them. And also there was a model for them being able to get incentivized and for healthcare to be paid for the innovation. I think the issue with perhaps the innovation is that there has to be somebody who pays for the innovation. It is easy for pharma companies to invest more money into innovation but more or less what happens is that a lot of that innovation starts getting positioned to markets which have active models to pay for it. Because you have to recover the cost as Dr. Kang said, you have to cover the cost of your innovation in some way or the other. And, I think we must have an act, you know the government started the universal health coverage, I think that's a phenomenal thing because it allows at least so many patients to get cured and for Indian companies to realize that there is a funding mechanism in the house by virtue of drugs being bought and more patients can be put on these medications and drugs. I think the funding model is extremely important for any innovation environmental system.

**David Bloom:** One has to recover the cost of innovation but that also includes the cost of failed innovations and innovations can fail for a lot of reasons, not just because it didn't work but there are competitors and if someone came up with a cure for Covid, the value of the vaccine initiative would be very depreciative. So, there are a lot of sources of risk here and I do like the idea though Tarun of a global patent pool, I think that makes a lot of sense so that's worth developing. I think Cepi's also working on a fair allocation mechanism for the vaccines they develop, I like that idea as well.

**Tarun Khanna:** I mean, you know I was listening to something on one of the news channels and they were taking about these advanced market commitments that I'd mentioned briefly as another mechanism to reassure big pharma that yes there will be a part of money at the end of the rainbow so you should invest in capacity and what have you, and then it occurred to me that even the AMCs, the advanced market commitments are only credible if the underlying state is credible, if the underlying government is credible, or the entity that's giving the commitment is credible. So you have many of these polities in the developing world that give a promise and then either directly or indirectly violate the promise and don't follow through on the commitment, it really blows a hole in the fabric of trust that's needed to make this whole system work.

As a lot of comments are, all three of the panelists have mentioned things that are about maintaining balance in a different sense whether it scientific balance, economic balance, financial balance to get this kind of a symphony working correctly. Sorry for mixing metaphors, so you know I was talking to one of our vaccine manufacturers and they said that in the one of the prior epidemics, maybe it was H1N1 I can't remember, the idea was that the government would buy the capacity but it wasn't clear whether that commitment was entirely carried through. I don't know the facts about this entirely but if that's the case I know it's happened in Latin America then it really makes it difficult to have this reassurance. It's all just different way of saying there are so many parties here whose interest have to be aligned all the way from scientists to the community health workers on the ground. And unless we get this balance right, which is tricky of course as David pointed out, it becomes very hard. What I want to do is just go through the panelists again in the same order and just see if they have any final comments based on the conversation or maybe things that you would encourage the audience and society at large to think about as work our way through this difficult time. Gagandeep, would you like to go first please?

**Gagandeep Kang:** I think one of the things other than the vaccine succeeding that's encouraging is the act accelerator, which is the access to Covid-19 tools that's been put together by the Gates Foundation, the Wellcome Trust, the WHO, Gavi's part of it and it focuses on vaccines, therapeutics and diagnostics but the nice thing about it is that there are multinational companies involved as well as the developing country vaccine manufacturers, at least where vaccines are concerned. So, this has become a platform where people are actually talking about how we get vaccines to people who need them the most. It doesn't matter who makes the vaccine, how quickly can we get these vaccines made and delivered and recognizing that we're not going to be able to vaccinate the whole world in one go, is there an approach that we can take to prioritization, so we make sure that the people who are most in need can get vaccines quickly. So, seeing the world come together like that is really encouraging.

**Tarun Khanna:** I share that enthusiasm, thank you very much. David?

**David Bloom:** So, what I would like to see is a move, which I think is also going to happen is a move to new pattern of sustained and large-scale commitments to vaccine development and I think that's going to be a movement that takes advantage of everything the private sector has to offer, that encompasses big pharma as well as non-big pharma developers and manufacturers. And I think we basically have a crisis now, a crisis is also an opportunity and I think the idea that you floated before Tarun about global patent pools, I think it's a good time to develop a plan and to kind of. I feel like Cepi is a big step in that direction, I think we can take that further. I think in the end just in terms of more commitment, I think we've already invested we just need to invest a lot more money into vaccine development and again, I think we are going to have somewhat ironically Covid-19 to thank because it is providing irrefutable proof of the colossal benefits of staying the course when it comes to the developing, manufacturing, delivery of vaccines. The problem is there are so many pathogens out there that lurk in our future, there are literally dozens that are known, and obviously many, many more that are unknown and I think that's a big challenge. So, I do ideate also thinking that it's some kind of half-baked cake, developing a lot of vaccines halfway so if a pathogen becomes close to an outbreak then we can actually finish it off and move quickly, which is something we haven't been able to do with regard to Covid-19.

**Tarun Khanna:** Yeah, it's astounding. I just saw I think it was a Twitter feed from Anthony Fauci who has become famous in the US as a spokesman for fighting Covid, saying that it would probably not have cost more than two billion dollars to create a platform for vaccine many years ago, which would have made getting the Covid vaccine up and running much faster. So, the magnitude to me seems like a tiny drop in bucket given the hundreds of trillions that will be lost. Thank you, David. Umang?

**Umang Vohra:** Yeah, Tarun. I think the world is at a much better place today than 10 years back or even five years back or as Dr. Kang said six months back to solve this problem and I think there is tremendous hope in the vaccine and I'm just saying that the ability of getting this vaccine to be accessible is another journey and it's equally long journey of hope that all of us need to sign up for whether it is the governments or all of us as private players. So, we are really excited to get onto that journey and I hope that we have dimension in mind as well rather than just the delivery of the vaccine.

**Tarun Khanna:** Thank you, Umang. Thank you to all the panelists for joining us. I'm very sorry we went over by five-six minutes but I appreciate everybody's time and thank you for supporting all our efforts at Harvard and across India and different organizations and have a good rest of the day if you are in my part of the world and good evening if you are in India and that side of the world. Thank you all.