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Commentary

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The costs of coronavirus vaccines and their pricing

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The highly infectious coronavirus has caused a global pandemic of disease and death that, through the rapid transmission of mutations like the Delta variant, exploits vulnerabilities and inequalities in communities, nations and across the world. Worse, the pandemic fosters massive unemployment, threatens economic growth, increases inequality and incites social unrest in a vicious self-reinforcing cycle.[1] Because 'nobody is safe until everyone is safe' and affluent nations cannot address this issue alone, COVID-19 vaccines need to be as globally affordable and accessible as possible as a public health good to help counter this threat to global public health. Cost is clearly not the only reason that vaccines are not reaching vulnerable populations in low- and middle-income countries. Other factors such as corrupt politicians, poor transport links and the inability to maintain a cold chain are all important contributors. However, even if these were corrected, an unaffordable vaccine is the equivalent of no vaccine for the majority of countries. For this reason, our commentary focuses on vaccine costs.

More than other medicines, vaccines are regarded as a public health good because they are administered to whole populations to protect them from serious risks of illness or death. As appropriate for a global pandemic, public funding to corporations has directly or indirectly financed all phases of vaccine research, development, testing and manufacturing, including the development of the innovations on which the RNA platform (mRNA) and other vaccines are based.[2] Billions in funding from taxpayers, multiple branches of the United States (USA) government,[3] from the European Union (EU) and countries such as Germany, has been so extensive that there is little investment or sunk costs for corporations to recover, except perhaps for those associated with manufacturing the vaccines themselves. In addition, company costs for liability are minimised, as are the large marketing costs typical of pharmaceutical products.

If companies primarily only need to recover their manufacturing costs, along with a reasonable profit that is acceptable to both sellers and buyers, then the question is what should a fair vaccine price be? AstraZeneca has said it is selling its Oxford-based vaccine without profit during the global pandemic, but its inter-country price per dose varies – $2.15 in Europe, $3–4 in the USA and $5.25 in South Africa – and the lack so far of any independent verification of cost[4] raises the question of the veracity of its claim. According to a *BMJ* report in January 2021, Moderna and Pfizer were charging more affluent nations and the EU for their mRNA vaccines with prices ranging from $14.70 to $23.50 a dose.[5] Do their costs of developing and manufacturing vaccines, net of public subsidies, justify these prices, or are the companies just 'making a killing' as a recent *BMJ* commentary put it?[6]

As with prices, and contrary to the ethics of vaccines as a public health good, companies have kept manufacturing costs for all vaccines secret, and only a few independent studies have researched them in detail.[7] Our analysis is based on this literature as well as an in-depth investigation done with Doctors Without Borders.[8] Still, lack of company disclosure of costs means that our estimates will remain educated guesses until government purchasers demand evidence of verifiable costs. In that case, government agencies such as the Government Accountability Office (USA), National Audit Office (UK) and the Court of Auditors (EU) could produce far more accurate estimates of vaccine costs. To date, governments have not taken this step, and manufacturers are being allowed to keep their costs secret on these global public health goods.

Net costs of manufacturing

Let us start with what is called the 'cost of capital', to build, equip and replace over time a large, modern vaccine plant. Based on two large, fully equipped, state-of-

the-art facilities in the USA and EU, the high estimate of the most recent study, when spread out over 100 million doses a year and annualised over the life of the plant and equipment, comes to only about US$ 0.20 a dose.[8] A retrofitted factory or a new factory in India or China costs much less,[8] and major public funding to build, expand, retrofit and equip plants for COVID-19 vaccines means that companies have little or no net investment in manufacturing facilities to recover.

To this cost, one must add the annual costs of a large, highly skilled and experienced staff. Manufacturing modern vaccines is a complex process and requires this type of staffing to oversee extensive testing for purity, safety and consistency. Based on 100 million doses a year, staffing at US or EU levels costs about US$ 0.18 a dose, including factory and administrative overhead. A reasonable estimate for comparable staff in the Developing Country Vaccine Manufacturers Network would be about half or US$ 0.09 a dose.[8]

A third cost is the vaccine substance itself. The *New York Times* reported that the substance of the Johnson & Johnson vaccine costs US$ 0.30 a dose.[9] Other vaccine substances may cost more or less (see below). A fourth, so-called fill-and-finish cost to make vials ready for shipping is about US$ 0.30 for single-dose vials, but half or less for multi-dose vials.[8] We estimate fill-and-finish costs range from US$ 0.15 to US$ 0.30 a dose, based on 100 million doses a year.

Adding these costs together, net manufacturing costs for 100 million doses ready for shipping appear to range from US$ 0.54 to US$ 0.98 a dose. A recent detailed study of adenoviral vector vaccine unit costs finds them to be substantially lower than these estimates.[10] The mRNA coronavirus vaccines seem to cost less than other vaccines to manufacture, although, as we have pointed out above, they are being sold for more than the price of vaccines made through more established manufacturing processes. The *New York Times* reported that mRNA vaccines 'are relatively easier to manufacture' than live-virus vaccines.[11] Pfizer's senior vice president described making an mRNA vaccine 'as a clean, fast process that required a relatively small footprint to produce many doses'[12] and a detailed study substantiates her characterisation.[13]

Company executives and experts may claim production costs are much greater than our estimates but need to provide verifiable evidence of actual costs minus all forms of 'push' (grant, contracts) or 'pull' (patents, advance purchase commitments), direct or indirect taxpayer subsidies.[14]

Policy implications

This analysis has several important implications. First, given that these cost estimates include the sustainability of facilities, production lines, equipment and all manufacturing personnel, sustainable vaccine prices with a modest profit margin should be marginally more than the production costs for these global public health goods. They should be affordable to all but the 46 least developed countries. (Dealing with affordability for these countries lies outside the scope of this essay.)

Second, our cost estimates add support to low estimated costs by others. For example, an American group focused on increasing access to HIV medications, concluded it would cost the United States US$ 2.00 a dose to produce a global supply of the Moderna vaccine from US public–private manufacturing facilities.[15] A team from Imperial College London has modelled the costs for setting up a global network of facilities to produce eight billion mRNA COVID-19 vaccines within a year.[13] It details why all capital, personnel and material costs for Moderna's mRNA vaccine add up US$ 2.85 a dose. However, because Pfizer's vaccine uses much less mRNA and many fewer production lines, personnel and other resources, its costs add up to only US$ 1.18 a dose. The study also explains how the mRNA manufacturing process minimises future costs in modifying vaccines to deal with threatening mutations like the Delta variant.

Finally, companies are already increasing prices to wealthy buyers. An August report claims that Pfizer has raised its reported price in large European purchase agreements to $25.15 a dose and Moderna to $25.50.[16] Companies expect to charge many times more after they exercise their right to declare the pandemic is over.[17] These higher prices, despite discounts and tiered pricing for middle- and lower-income countries, are likely to prolong the global pandemic. Governments continue to finance most future research and development for coronavirus vaccines and underwrite the risk that companies take through large, heavily redacted advanced purchase agreements.[4] Governments must stop being partners in secrecy, and as purchasers they should demand public, verifiable reports on net costs, after direct and indirect taxpayers' subsidies, in order to set globally affordable cost-plus prices for these global public health goods. Until that happens, the question will be raised about whether both governments and companies are committing 'crimes against humanity'.[6]

Declarations

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