The Billion Dose Challenge: From a Delivery Perspective

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As the SARS-CoV-2 pandemic spreads, it is becoming clear that an effective vaccine will be a key milestone in alleviating fear and restarting the economy. Johnson & Johnson announced efforts to produce one billion doses of vaccine for SARS-CoV-2 and Bill Gates announced he will spend billions on factories for several promising vaccines.

History has shown that vaccine and vaccine delivery have been developed largely as humanitarian endeavors rather than purely profit motives, with the greatest demand in areas with developing healthcare systems. However, as the history of the measles and other vaccine demonstrated, the challenge of effective vaccination against an outbreak requires both an effective vaccine and improved accessibility.

Leaders such as Roche, Pfizer, and Johnson & Johnson are leveraging vast resources, experience, and development platforms to develop a vaccine in the coming months and years. The challenges of global vaccination campaigns during the pandemic has never been more palpable.

This moment represents a “once in a lifetime” opportunity where the challenge of addressing improved delivery and accessibility for the world’s population pales in comparison to the vaccine development effort. Progress made today will leave an impact far beyond the COVID-19 pandemic and benefit humanity for the next 50 years.

Issues of accessibility are well understood, but historically underserved due to the lack of a viable business model. Developed in 1963, the measles vaccine reduced reported cases by 50% between 1980 and 1986. It took an additional 20 years for new cases to be reduced by 90% and has stayed at the same level since. More recently, a group of health economists projected that delivering full vaccination programs to 94 countries would cost $64 billion dollars over 10 years, with $34 billion stemming from service delivery. At the same time, most of the worldwide demand is satisfied by nonprofit organizations that purchases at up to 97% discount from developed world prices.

Accessibility can be addressed through innovations in formulation, cold chain, and delivery devices. Efforts addressing accessibility challenges from a technology point of view will pay dividends well beyond the current pandemic and improve the lives of billions.

Economic Considerations

In an increasingly likely scenario, the novel coronavirus will continue to circulate in areas with developing healthcare systems where any new vaccine will take the longest to reach. Therefore, we must first understand the scale of the challenge of delivering a new coronavirus vaccine to areas with developing healthcare systems. For example, costs to introduce the human papilloma virus (HPV) vaccine ranged from $4.29 in Peru to $2.22 in Laos (Immunization Delivery Cost in Low-and Middle- Income Countries, Thinkwell Global, January 2020, pg. 15). For an existing vaccine, UNICEF spent $1.5 billion on 2.7 billion vaccine doses in 2014, averaging a price of $0.56 per dose.

To reach the billion-dose challenge, wastage and cold chain must be addressed. Are there design options that could tackle each of these issues? Consider:

Access
Technologies that enable self -administration are on the horizon but carry significant cost and development risks. Tried and true technologies that enable mass immunization at a facility while lowering the training requirements and variability has potential to be impactful.

Storage/Transport
The lack of ability to monitor and maintain control, lead to significant wastage and inefficiency. Various reports estimate that 75% to 100% of vaccines experience some non-optimal condition during transport and some 30% of vaccines are partially inactive at the time of administration (Transforming cold chain performance and management in lower income countries. Brison et.al., April 2017. Vaccine: 35(17): 2107-09).

Overhead
A significant component of overhead is delivery and service (i.e. staff to process patients and to administer the vaccine). A key usability challenge is how vaccine delivery strategy can enable non-healthcare professionals to deliver quality care.

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Delivery technology – A tried and true platform shines

Innovations and advances in delivery technologies face an uphill battle due to unfavorable unit economics and an overall lack of urgency. As part of the COVID-19 billion dose challenge, there is a time-sensitive, but tremendous opportunity to address and improve access through technology.

There is no lack of promising technologies such as Aquavit’s self-administered microchannel delivery device (a dissolvable microneedle array being developed by the University of Pittsburgh) and microfilm technology for oral delivery that improves thermal stability. Each technology will need to define a niche value proposition to find a place in the market but are unlikely candidates for the billion-dose challenge.

Meanwhile, disposable, needle free jet injectors are mature platforms that have well understood tradeoffs with clear advantages in mass immunization campaigns (WHO). A high- pressure delivery mechanism (springs, gas propelled, or gas generated) delivers a measured dose of vaccine from a bulk container quickly, effectively, and economically. Today’s devices addressed concerns with wetting and contamination in previous generations and are well suited for mass immunization programs.

In our experience, the economics of a jet injector with a disposable cartridge can be competitive with options to optimize volume or cost. Consider a battery-operated jet injector capable of firing 6-10 times per minute costs, costing less than $800 USD per unit at scale, and can deliver vaccines at below $0.08 USD per injection. The firing motor is the most expensive component (~30-40% of total cost) and dictates reliability, repeatability, and quality of injection.

Key cost benefit considerations are:

1. Power and motor mechanism (manual / pneumatic / plug-in / battery)
2. Safety (Trigger, no cartridge, misfires, touch points)
3. Cartridge and filling (single use, anti-slip, packaging, and touchpoints)
4. Filling station (manual, semi-automatic)
5. Scalable delivery of training and instruction for use

Cold Chain: Innovation and impact beyond SARS-CoV-2

The global vaccine demand is exploding driven almost entirely by demand in areas with emerging healthcare systems. This doesn't include any projections of a SARS-CoV-2 vaccine. Accidental freezing occurs in 33% of storage facilities in wealthy countries and 37% of facilities in nascent economy countries. Cold chain equipment is failing and underperforming in 20 and 50% (respectively) of 55 Gavi-eligible countries.

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In Ethiopia, a 1% increase in vaccine wastage due to poor temperature control would result in losses of over US $8 million of vaccines per annum. In Nigeria, the average time to repair a refrigerator at the lower government area (LGA) level ranged from two months to two years, and 29% of all vaccines are subjected to freeze risk.

The existing capacity in today's cold chain will not accommodate the massive vaccination program that is expected for the novel coronavirus. The current focus on vaccination represents a clear and urgent opportunity to re-imagine a post-COVID-19 vision of a purpose built, scalable, and connected cold chain for the next century.

An excellent review of current cold chain gaps and improvements was presented by LeTallec et al as viewed by the Clinton Health Access Initiative (CHAI). In the review, the authors highlight three major gaps: (1) insufficient cold chain capacity, (2) unsafe technology and slow adoption of better equipment, and (3) inadequate temperature control and maintenance systems.

In light of the existing capacity challenges highlighted by the review and the expected worldwide inoculation campaign against SARS-CoV-2, there is an opportunity in the context of the massive sums being spent to develop a vaccine. Looking closer, a ground up, purpose-built vehicle that address the fundamental challenges of the cold chain, will cost a fraction of the total cost but have an out-sized impact on human health.

The vision is a purpose-built vaccine cold chain platform that will roll out with the introduction of the SARS-CoV-2 vaccine, optimistically in 12-18 months. The design is centered around modularity, scalability, and reliability. The design should encompass the following discernible features to overcome a unique set of requirements:

1. Scalable and efficient: A core menu of components, materials, and a modular design, used across the continuum of transport. Designing for thermal efficiency is achieved by properly managing conductive, convective, and radiative thermal losses. Novel insulating and reflective materials along with Phase Changing Materials (PCM) will enable a combination of passive and active cooling to achieve high thermal efficiency.
2. Reliability and Usability: By reducing parts count and properly defining use requirements, this design should have the required durability demonstrated by design verification and design validation testing. A focus on usability means there will be no special installation protocols, nor any maintenance required, and repairs are done by swapping compatible modules.

3. Longevity: By utilizing advanced materials and smart cooling, longevity is enhanced and can be further augmented by offering additional options. These options for users can include adaptors for solar charging, circuit ability to be partially charged via a handheld, mechanical, handle-rotating charger, and the ability to accept ice in certain chambers to maintain temperatures. Individual vaccines can be "quick" ejected in a way that minimizes exposure of the remaining vaccines in the unit to ambient temperature.
4. Connectivity: Continuous temperature monitoring with wireless remote connectivity ensures proper temperature maintenance within 5-8 degrees and alert capability allows quick actions from users to preserve vaccines.

A CALL TO ACTION

A lasting impact

At Ximedica, our organization is purpose built to deliver innovation and execution with our clients to rapidly respond to market demand. Like many of our clients and partners, as we felt the impact of COVID19, our team shifted focus to how Ximedica can leverage our expertise to solve an unmet need.

We quickly identified the vaccine cold chain as a key unmet need that 1) had a product / design component, 2) lacked a clear business incentive in non-crisis times and 3) positively impact billions of lives both during the current pandemic but for decades after. As countries and companies pour billions of dollars into COVID19 vaccine and therapy development, a small fraction of that funding would help make sure the world's population has safe and equal access to this and every other vaccine.

A well-studied, but chronically underfunded challenge, the vaccine cold chain today is piecemealed with aging, incompatible, and insufficient infrastructure that is straining under an expanding vaccine demand. Our designers, engineers, and business development teams came together to envision a "common platform" for a next generation of vaccine cold chain that focus on scalability, usability, and connectivity.

We are currently hard at work developing this concept and will present the proposal this month via a follow-on whitepaper and presentation. In the meantime, please join our conversation if your company or organization is working to improve global access to the COVID19 vaccine. Drop us a message by reaching out to Michael Neidert, VP of Strategic Development (mneidert@ximedica.com) or Sheila Trgovac, VP of Strategic Development (strgovac@ximedica.com).

Ximedica is a full-service ISO 13485-certified and FDA-registered product development firm. For 30 years Ximedica has provided a unique growth platform enabling organizations to successfully deploy medical technology products into the market.