The Combined Effect of Vaccination and Nonpharmaceutical Public Health Interventions—Ending the COVID-19 Pandemic

Alexander Doroshenko, MD, MPH

Since the emergence of the first cases of SARS-CoV-2 infection in late 2019 and the declaration of a global pandemic in March 2020, the public health and economic impacts of the COVID-19 pandemic have been substantial. The impact of the pandemic is being felt around the world, and in its early stages, only a few countries were successful in limiting community transmission by early and proactive public health measures aimed at preventing importation and seeding of infection in their jurisdictions. As we collectively learned about this new pathogen and its transmission routes and patterns, most countries relied on public health measures based on previous experience of epidemics of respiratory pathogens with human-to-human transmission to mitigate the effects of COVID-19 infection. These measures included isolation and quarantine, stay-at-home orders, closure of nonessential businesses and schools, physical distancing, limiting social interactions, and enhanced respiratory hygiene, collectively known as nonpharmaceutical interventions (NPIs). These interventions were later supplemented by the recommendation and/or mandate that the public wear nonmedical masks with the aim of reducing transmission at the population level.1 As unintended consequences and the economic toll of public health restrictions continue to mount, a strategy to end this pandemic logically involves deploying effective and safe vaccines. There are several vaccines, mostly based on messenger RNA and nonreplicating viral vector technologies, now approved for use by regulatory authorities around the world. Because the rollout of vaccination campaigns around the world still depends on vaccine supply and available public health infrastructure, it is only natural to ask when we can roll back public health NPIs.

Elsewhere in JAMA Network Open, Patel et al2 describe an agent-based mathematical modeling approach to simulate several scenarios of different vaccine effectiveness and vaccine coverage associated with maintaining or discontinuing NPIs within a large representative sample of a synthetic population (agents) of more than 1 million people in North Carolina. The population was further stratified by ethnicity/race and urban/suburban/rural settings based on census data. The model was parameterized to characterize the underlying transmission dynamics of SARS-CoV-2 infection and calibrated and validated against public health surveillance data in North Carolina. Vaccination was implemented in the model during 6 months by transitioning individuals into a recovered/immune state. The NPIs represented in the model included quarantine, school closures, social distancing, and mask wearing, which were modeled by implementing the reduction in transmission rates associated with these interventions over time. By generating the model’s projections of the number of infections, hospitalizations, and deaths during an 18-month period and comparing these outcomes for several scenarios, the authors found some interesting results. First, it is apparent that lifting NPIs while rolling out vaccinations was associated with a significant increase in the number of infections, hospitalizations, and deaths across the range of vaccine effectiveness and vaccine coverage assumptions. Second, achieving a higher vaccine coverage leads to a greater reduction in the number of infections, even with the relatively lower vaccine effectiveness in the absence of NPIs with a combination of 75% coverage and 50% efficacy, resulting in a greater risk reduction compared with 25% coverage and 90% efficacy. Third, the cumulative incidence of infections, hospitalizations, and deaths varied by ethnicity/race and place of residence across different scenarios, with African American persons and residents of rural areas faring the worst.2
Generally, the results reported by Patel et al.\textsuperscript{2} are consistent with the findings from other studies that have examined the interplay between public health interventions and COVID-19 vaccination. For example, Moore et al.\textsuperscript{3} used an age-structured mathematical model that was calibrated to the historical data on positive test results, hospitalizations, and deaths in UK regions to forecast the reproductive number (R) based on predicted future growth rate of subsequent waves of infection and the pattern of daily deaths to 2024. The model included a representation of a 2-dose vaccination schedule with immunity starting at 14 days, rolled out in a phased manner with decreasing age guiding the sequence of vaccinations, and assuming an age-dependent uptake of the vaccine ranging from 75% to 95%. The model predicted that in the absence of NPIs, the future R would remain elevated at 1.58 (95% credible interval, 1.36-1.84), even with most eligible adults receiving both doses of vaccine, based on the modeled vaccine coverage, for the vaccine offering 85% protection against the infection (against the counterfactual scenario of no protection against infection, in which R was estimated at 3.15). The vaccination program, however, substantially reduced total deaths.\textsuperscript{3} Although these studies have methodological differences and different context, with the study by Moore et al.\textsuperscript{3} capturing vaccination strategy in a more granular way and examining longer-term trends, and the study by Patel et al.\textsuperscript{2} using agent-based simulations with a greater representation of the heterogeneity of contact patterns, they both agree on the risks associated with the early relaxation of NPIs, even in association with vaccination. Moreover, the trade-off between COVID-19 vaccine effectiveness and vaccine coverage without NPIs was examined in a study by Bartsch et al.\textsuperscript{4} The optimal combination was reported as 75% coverage with 70% efficacy; however, in their study, the end point was to extinguish the epidemic.

Pertinent to the effects of NPIs and vaccination, the context of the recent recommendations made by the US Centers for Disease Control and Prevention for vaccinated individuals should be considered. They recognize that NPIs encompass a heterogenous group of actions and social behaviors. They emphasize the need for a balanced approach to allow vaccinated individuals to resume low-risk activities while acknowledging that social distancing and mask wearing should still be important interventions during vaccination implementation.\textsuperscript{5} From this perspective, Patel et al.\textsuperscript{2} offer useful insight by modeling varying efficacy and adherence of mask wearing. The latter model tested a scenario in which most vaccinated individuals would no longer be using masks. Given the findings of the disproportionate burden of COVID-19 among ethnic/racial minority populations\textsuperscript{2} coupled with evidence of increased vaccine hesitancy among the same groups,\textsuperscript{6} future studies should explore how lifting NPIs can motivate individuals to get vaccinated, as discussed in the Centers for Disease Control and Prevention recommendations. Furthermore, key evidence on the effectiveness of COVID-19 vaccination against an asymptomatic state and transmission continues to emerge, with the recent postmarketing cohort study among health care workers in the US reporting messenger RNA vaccine effectiveness of 90% 14 days after the second dose, regardless of symptom status.\textsuperscript{7} Public health policies based on this new evidence will continue to be adapted. Future studies should further examine the differential effects of various NPIs in combination with vaccination.

It is timely to have a scientific debate about the optimal strategy to control and ultimately stop the COVID-19 pandemic. It is important to recognize that NPIs and vaccination minimize the impact of the pandemic through distinct mechanisms: the former decrease the effective transmission rates, and the latter increases the number of people who are nonsusceptible to infection or to severe outcomes of infection in the population. In the short and medium term, continuing NPIs will likely have an effect that is complimentary or even synergistic to vaccination in the effort to end the COVID-19 pandemic.
Corresponding Author: Alexander Doroshenko, MD, MPH, Division of Preventive Medicine, Faculty of Medicine and Dentistry and School of Public Health, University of Alberta, 5-30 University Terrace, 8303-112 St NW, Edmonton, AB T6G 2T4, Canada (adoroshe@ualberta.ca).

Author Affiliation: Division of Preventive Medicine, Faculty of Medicine and Dentistry and School of Public Health, University of Alberta School, Edmonton, Alberta, Canada.

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REFERENCES


