News and Views: The Promise of Vaccinology

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Introduction

In the early days of vaccination, the field weathered the share of criticism due to any scientific advance. The positive outcomes of vaccination were balanced by the ambiguity of statistical evidence for its safety[1]. Alfred Wallace who co-discovered Evolution with Darwin, advocated the exercise of caution[2]. Anti-vaccinationism found a place in the Nazi theories of racial superiority and exploitation of evolutionary theory. Sample an argument: 'Immunity to disease indicates that the individual is robust, therefore vaccination prevents the operation of natural selection. 'Such objections are perverse and at odds with the chief object of medicine, namely to provide succour to the sick[3]. The utility of vaccination as a method to create memory in the immune system using the agent of disease itself but without its virulence factors is today firmly established. Vaccine research has yielded effective prophylaxis in many cases. We are heavily anticipating vaccine breakthroughs for many more conditions, including some cancers.

Hurdles to effective vaccination

- Design of the vaccine: A balance must be achieved in the attenuation of the virus/pathogen to be used as the agent of vaccine. Too attenuated, and the memory might become non-specific and not of much use. Too virulent, and the vaccination might itself lead to complications. The polio vaccine, a genuine triumph of vaccinology, was falsely associated with risk of seizures and neurological conditions. More recently, claims that autism and developmental regression were associated with the long-term sequelae of childhood measles-mumps-rubella vaccination have been thoroughly debunked[4].
- Coverage of vaccination: If a sufficiently large fraction of the population is vaccinated, then the un-vaccinated proportion of the population could be protected against the disease through a phenomenon known as herd immunity. If more members of the population remain unvaccinated, then herd immunity breaks down. A fine line separates the emergence of herd immunity and the outbreak of disease.

Optimising vaccination

To draw a simple analogy, consider insurance. Ideally everyone (i.e. 100%) should be covered, but in practice there will be the uninsured few among us. In the context of vaccination, suppose we have an effective vaccine against a certain infectious agent. If more parents in the population are phobic to vaccination, then the personal decision to vaccinate is biased, and one could skip vaccination, instead relying on herd protection. This will lead to the incidence of the disease in the population, and an outbreak of the disease in the worst case.

An alternative scenario consists in viewing vaccination as a public good where the state mandates a policy of compulsory vaccination. This interpretation involves the following caveats:

- Citizens should be wary of fallacious policies imposed by compulsory legislation;
- On the other hand, public goods are not adversarial to personal freedom. For example, consider a state policy of net neutrality – where the internet remains open for everyone's access and free from corporate manouevrings. This is essential to a democratic internet.

If vaccination is enforced by the government as a public good, it could eventually lead to the elimination of the disease reservoir. This strategy is not free of controversy. Even if the disease were controlled below its basic reproductive ratio[5], a latent reservoir of the pathogen in just a very few individuals could form the testbed of evolution. In the absence of absolute coverage, the selection pressure for the emergence of resistant pathogen strains is active and forceful. In the event that resistance emerges, the virulence of the pathogen might likely be amplified, leading to a serious question of public health, and a challenge for biomedical research. The evolution of resistance poses one of the key challenges for medicine in this century.

Conclusion

Strategies for vaccination must be optimized to control the outbreak of crises in public health. For life-threatening infectious diseases, complete coverage of vaccination is our surest ally. Planned mass immunization could help avert the recurrence of disease in the population. In complementation with the safety of vaccination, the treatment of disease at its source would be the appropriate requisite.

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