APPENDIX

A1. Documentation of pub-med searches to identify experts with significant contributions and expert elicitation and review process

The process for selecting experts relied on evaluation of the existing literature to identify researchers with significant contributions, which the first and last authors (RJDT and KMT) characterized as authorship on multiple peer-reviewed, published studies in the following 6 categories of studies, excluding papers published in English before 1990.

A: OPV challenge studies

20 studies listed previously known to RJDT + 3 studies identified in new searches

B. Reviews

Keyword Polio AND publication type Review AND any field (Immunity OR Immunology): 150 hits

After selection based on abstracts: 14 relevant papers + 2 identified in later searches + 5 book chapters previously known to RJDT

C. Kinetics of antibody response

Keyword Polio AND any field Kinetics: 31 hits

Keyword Poliovirus AND any field Kinetics AND any field Antibody: 41 hits

Combined 69; after selection: 4 relevant papers

D. Mucosal immunity (polio-specific)

Keyword Poliovirus AND any field Mucosal AND any field Immunity: 35 hits

After selection: 6 relevant polio-specific studies

E. Mucosal immunity (not polio-specific)

Title Mucosal AND title Immunity: 703 hits

After selection: 77 potentially relevant papers

F. Immunogenicity

Keyword (Polio OR Poliovirus) AND any field Vaccine AND any field Immunogenicity: 78 hits

After selection: 39 potentially relevant papers+ 5 identified in prior searches

We selected experts from the lists of authors with multiple publications obtained through these searches, placing the most weight on authorship of OPV challenge studies, and considering continued involvement in polio-related research. The expert selection process identified 10 experts. The CDC convened the Expert Meeting on Poliovirus Immunity and Transmission in Atlanta, GA on April 13 and 14, 2010, which 9 of the experts (KMC, NAH, TH, PDM, JFM, MAP, PAP, RWS, PFW) attended (a tenth expert encountered a schedule conflict and decided not to participate in the process due to competing demands), and two authors from the CDC (SGFW, SLC) were invited to the meeting. Prior to the meeting, several of the authors (RJDT, MAP, SGFW, SLC, JHK, KMT) developed a comprehensive background document that provided a preliminary overview of the literature, which served as the foundation for an overall expert review of the literature and for the elicitation.[25]

During the meeting, the process began with the identification of 8 immunity states as the minimum set required to model immunity to poliovirus transmission (described in detail elsewhere[25]) and used to facilitate the collection of expert input. The meeting then systematically covered key topics related to these 8 immunity states, with review and discussion

of the available data from the literature followed by expert elicitation. For the elicitation, we sought to elicit relationships over time or between quantities using tables or graphs. For both elicitation formats we encouraged experts to provide their best estimate, defined as the 50th percentile, and the 5th and 95th percentiles of their uncertainty distributions about the 50th percentile. After the meeting, the authors reviewed the raw assessments and engaged in an iterative process to ensure consistent interpretation of the elicited quantities and questions, which led to the development of the synthesis presented here. This process included several discussions of the results with the group via teleconference, which led to the identification of specific questions for follow-up with each expert individually. To facilitate this follow-up, the first and last authors (RJDT and KMT) developed a large MS Excel^{TM} spreadsheet for each expert that allowed the expert to edit and verify his assessment on each topic, see the impact in the form of graphical output, and respond to queries. We did not include the elicitation of 5th and 95th percentiles in the spreadsheets given the large amount of assessments requested and the challenges associated with obtaining these for all assessed quantities during the initial elicitation. Thus, we focused on the best estimates (i.e., 50th percentiles) for each expert. The lead author (RJDT) discussed the spreadsheet with each individual expert to clarify definitions as needed and understand the expert responses to queries.

A2. Derivation of contribution to transmission for historic immunity states

We use the notation from the main paper, with dependence on time t following the exposure and time s since entering the immunity state indicated as the two dependent variables, but the dependence on s dropped for fully susceptibles because no waning occurs for fully susceptibles.

We must determine P(t) and C(t) for the historic immunity states based on the assessed increases in TV in order to determine CT(t) for the historic immunity states. To do so, we make two assumptions:

1) At each point in time, the relative increase in A(t) equals the relative increase in TV = ∫A(t)dt
2) At each point in time, the relative increase in P(t) equals the relative increase in C(t)

Given immunity state i and assessments for the increase in total virus output wtv(s), then the first assumption says that for all t:

$$A(t,s)^i = A(t,0)^i + wtv(s)(A(t)^{FS} - A(t,0)^i)$$
$$\Rightarrow P(t,s)^i C(t,s)^i DO = P(t,0)^i C(t,0)^i DO + wtv(s)(P(t)^{FS} C(t)^{FS} DO - P(t,0)^i C(t,0)^i DO)$$
$$\Rightarrow P(t,s)^i C(t,s)^i = P(t,0)^i C(t,0)^i + wtv(s)(P(t)^{FS} C(t)^{FS} - P(t,0)^i C(t,0)^i)$$

The second assumption says that for all t:

$$P(t,s)^i = P(t,0)^i + f(t)(P(t)^{FS} - P(t,0)^i)$$
$$C(t,s)^i = C(t,0)^i + f(t)(C(t)^{FS} - C(t,0)^i)$$
$$\Rightarrow P(t,s)^i C(t,s)^i = P(t,0)^i C(t,0)^i + f(t)(P(t,0)^i (C(t)^{FS} - C(t,0)^i) + C(t,0)^i (P(t)^{FS} - P(t,0)^i))$$
$$+ f(t)^2 (C(t)^{FS} - C(t,0)^i)(P(t)^{FS} - P(t,0)^i)$$

Where f(t) is the relative increase in P(t) and C(t). Equating the right-hand sides of the equations resulting from both assumptions and solving the quadratic equation for f(t) for all t, we get as only non-negative root:

$$f(t) = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

where

$$a = (C(t)^{FS} - C(t,0)^{i})(P(t)^{FS} - P(t,0)^{i})$$
$$b = P(t,0)^{i} C(t)^{FS} + C(t,0)^{i} P(t)^{FS} - 2C(t,0)^{i} P(t,0)^{i}$$
$$c = -wtv(s)(P(t)^{FS} C(t)^{FS} - P(t,0)^{i} C(t,0)^{i})$$

For these calculations, we express C(t) on a natural scale and wtv(s) as the increase in TV on a natural scale.