United States (for example, 19A and others). See O'Brien *et al*., 2004, *Am J Epidemiol* 159:634-44; Whitney *et al*., 2003, *N Engl J Med* 348:1737-46; Kyaw *et al*., 2006, *N Engl J Med* 354:1455-63; Hicks *et al*., 2007, *J Infect Dis* 196:1346-54; Traore *et al*., 2009, *Clin Infect Dis* 48:S181-S189.

U.S. Patent Application Publication No. US 2006/0228380 describes a 13-valent pneumococcal polysaccharide-protein conjugate vaccine including serotypes 1, 3, 4, 5, 6A, 6B, 7F, 9V, 14, 18C, 19A, 19F and 23F. Chinese Patent Application Publication No. CN 101590224 A describes a 14-valent pneumococcal polysaccharide-protein conjugate vaccine including serotypes 1, 2, 4, 5, 6A, 6B, 7F, 9N, 9V, 14, 18C, 19A, 19F and 23F.

Other PCVs have covered 7, 10, 11, or 13 of the serotypes contained in PCV-15 (U.S Pub. No. 2011/0195086), but immune interference has been observed for some serotypes (e.g. lower protection for serotype 3 in GSK's PCV-11) and lower response rates to serotype 6B in Pfizer's PCV-13 (PREVNAR® 13). See Prymula *et al*., 2006, Lancet 367:740-48 and Kieninger *et al*., Safety and Immunologic Non-inferiority of 13-valent Pneumococcal Conjugate Vaccine Compared to 7-valent Pneumococcal Conjugate Vaccine Given as a 4-Dose Series in Healthy Infants and Toddlers, presented at the 48th Annual ICAAC/ISDA 46th Annual Meeting, Washington DC, October 25-28, 2008.

The current multivalent pneumococcal vaccines have been effective in reducing the incidence of pneumococcal disease associated with those serotypes present in the vaccines. However, the prevalence of the pneumococci expressing serotypes not present in the currently available vaccines has been increasing. Accordingly, there is a need for additional pneumococcal vaccine compositions which can provide protection against pneumococcal serotypes not present in currently available vaccines.

## SUMMARY

The disclosure provides multivalent immunogenic compositions comprising *S. pneumoniae* polysaccharide protein conjugates, wherein each of the conjugates comprises a polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, and wherein the polysaccharide protein conjugates include polysaccharides of a group of *S. pneumoniae* serotypes selected from the group consisting of:

a) 1, 3, 4, 5, 6A, 6B, 7F, 9V, 10A, 12F, 14, 15A, DeOAc15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B;

b) 1, 3, 4, 5, 6A, 6B, 7F, 9V, 10A, 12F, 14, 15A, 15C, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B;

c) 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 12F, 14, 15A, DeOAc15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B;

v) 1, 3, 4, 5, 6A, 7F, 8, 9V, 10A, 12F, 14, 15A, 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B;

w) 1, 3, 4, 5, 6B, 7F, 8, 9V, 10A, 12F, 14, 15A, 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B;

x) 1, 3, 4, 5, 6C, 7F, 8, 9V, 10A, 12F, 14, 15A, 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B;

y) 1, 3, 4, 5, 6A, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B;

z) 1, 3, 4, 5, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B; and

aa) 1, 3, 4, 5, 6C, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B.

The disclosure provides a multivalent immunogenic composition comprising 22 distinct polysaccharide protein conjugates, wherein each of the conjugates comprises a capsular polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, wherein the polysaccharide are prepared from *S. pneumoniae* serotypes 1, 3, 4, 5, 6A, 6B, 7F, 9V, 10A, 12F, 14, 15A, 15C, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B.

The disclosure provides a multivalent immunogenic composition comprising 22 distinct polysaccharide protein conjugates, wherein each of the conjugates comprises a polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, and wherein the polysaccharide protein conjugates include polysaccharides of a group of *S. pneumoniae* serotypes selected from the group consisting of: 1, 3, 4, 5, 6A, 6B, 7F, 9V, 10A, 12F, 14, 15A, 15C, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B.

The disclosure provides a multivalent immunogenic composition comprising 23 distinct polysaccharide protein conjugates, wherein each of the conjugates comprises a capsular polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, wherein the polysaccharide are prepared from *S. pneumoniae* serotypes 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 12F, 14, 15A, 15C, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B.

The disclosure provides a multivalent immunogenic composition comprising 23 distinct *S. pneumoniae* polysaccharide protein conjugates, wherein each of the conjugates comprises a capsular polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, wherein each distinct polysaccharide protein conjugate comprises a polysaccharide from *S. pneumoniae* serotypes 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 12F, 14, 15A, 15C, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, respectively, and wherein the carrier protein is CRM197.

The disclosure provides a multivalent immunogenic composition comprising 24 distinct polysaccharide protein conjugates, wherein each of the conjugates comprises a capsular polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, wherein the

polysaccharide are prepared from *S. pneumoniae* serotypes 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, 15C, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B.

The disclosure provides a multivalent immunogenic composition comprising 24 distinct *S. pneumoniae* polysaccharide protein conjugates, wherein each of the conjugates comprises a capsular polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, wherein each distinct polysaccharide protein conjugate comprises a polysaccharide from *S. pneumoniae* serotypes 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, 15C, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, respectively, and wherein the carrier protein is CRM197.

The disclosure provides a multivalent immunogenic composition comprising 24 distinct polysaccharide protein conjugates, wherein each of the conjugates comprises a capsular polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, wherein the polysaccharide are prepared from *S. pneumoniae* serotypes 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B.

The disclosure provides a multivalent immunogenic composition comprising 24 distinct *S. pneumoniae* polysaccharide protein conjugates, wherein each of the conjugates comprises a capsular polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, wherein each distinct polysaccharide protein conjugate comprises a polysaccharide from *S. pneumoniae* serotypes 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, respectively, and wherein the carrier protein is CRM197.

In one aspect, the disclosure provides a multivalent immunogenic composition comprising 24 distinct *S. pneumoniae* polysaccharide carrier protein conjugates, wherein each of the conjugates comprises a polysaccharide of a particular *S. pneumoniae* serotype conjugated to a carrier protein, wherein the *S. pneumoniae* serotypes are 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, de-O-acetylated 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, and the carrier protein is CRM197, and wherein the composition does not comprise polysaccharide carrier protein conjugates containing polysaccharides of any other *S. pneumoniae* serotypes.

In another aspect, the disclosure provides a multivalent immunogenic composition comprising *S. pneumoniae* polysaccharide carrier protein conjugates, wherein each of the conjugates comprises a polysaccharide of a particular *S. pneumoniae* serotype conjugated to a carrier protein, wherein the *S. pneumoniae* serotypes consist of 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, de-O-acylated 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, and the carrier protein is CRM197.

In another aspect, the disclosure provides a multivalent immunogenic composition comprising *S. pneumoniae* polysaccharide carrier protein conjugates, wherein each of the conjugates comprises a polysaccharide of a particular *S. pneumoniae* serotype conjugated to a carrier protein, wherein the *S. pneumoniae* serotypes consist essentially of 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, de-O-acylated 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, and the carrier protein is CRM197.

The disclosure provides a multivalent immunogenic composition comprising up to 33 distinct polysaccharide protein conjugates, wherein each of the conjugates comprises a polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, and wherein the polysaccharide protein conjugates include polysaccharides of a group of *S. pneumoniae* serotypes selected from the group consisting of: 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, 15C, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, further including one, two, three, four, five, six, seven, eight or nine additional *S. pneumoniae* serotypes selected from 7C, 9N, 16F, 21, 23A, 31, 34, 35F and 38.

The disclosure provides a multivalent immunogenic composition comprising up to 30 distinct polysaccharide protein conjugates, wherein each of the conjugates comprises a polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, and wherein the polysaccharide protein conjugates include polysaccharides of a group of *S. pneumoniae* serotypes selected from the group consisting of: 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, 15C, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, further including one, two, three, four, five or six additional *S. pneumoniae* serotypes selected from 7C, 9N, 16F, 23A, 35F and 38.

The disclosure provides a multivalent immunogenic composition comprising up to 33 distinct polysaccharide protein conjugates, wherein each of the conjugates comprises a polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, and wherein the

polysaccharide protein conjugates include polysaccharides of a group of *S. pneumoniae* serotypes selected from the group consisting of: 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, further including one, two, three, four, five, six, seven, eight or nine additional *S. pneumoniae* serotypes selected from 7C, 9N, 16F, 21, 23A, 31, 34, 35F and 38.

The disclosure provides a multivalent immunogenic composition comprising up to 30 distinct polysaccharide protein conjugates, wherein each of the conjugates comprises a polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, and wherein the polysaccharide protein conjugates include polysaccharides of a group of *S. pneumoniae* serotypes selected from the group consisting of: 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, further including one, two, three, four, five or six additional *S. pneumoniae* serotypes selected from 7C, 9N, 16F, 23A, 35F and 38.

In some examples, at least one of the polysaccharide protein conjugates is formed by a conjugation reaction comprising an aprotic solvent, e.g. dimethylsulfoxide (DMSO). In specific examples, each of the polysaccharide protein conjugates is formed by a conjugation reaction comprising an aprotic solvent, e.g. (DMSO).

Also provided are methods for inducing a protective immune response in a human patient comprising administering the multivalent immunogenic compositions of the disclosure to the patient. In some examples of the methods of the disclosure, the patient was previously treated with a multivalent pneumococcal vaccine.

A multivalent immunogenic composition of the disclosure may be used as part of a treatment regimen with a different, complementary pneumococcal vaccine. Accordingly, the disclosure provides a method of inducing a protective immune response in a human patient comprising administering a multivalent immunogenic composition of the disclosure to the patient, further comprising administering a multivalent pneumococcal vaccine to the patient in any order. In particular examples, the multivalent pneumococcal vaccine is comprised of multiple *S. pneumoniae* polysaccharide protein conjugates wherein each of the conjugates comprises polysaccharide from an *S. pneumoniae* serotype conjugated to a carrier protein. In other examples, the multivalent pneumococcal vaccine is comprised of unconjugated capsular polysaccharides.

The disclosure also provides multivalent immunogenic compositions comprising *S. pneumoniae* polysaccharide protein conjugates wherein each of the conjugates comprises a polysaccharide from a *S. pneumoniae* serotype conjugated to a carrier protein, wherein select serotypes of *S. pneumoniae* provide cross-reactivity to other select serotypes.

## BRIEF DESCRIPTION OF THE DRAWINGS

WHAT IS CLAIMED IS:

1. A multivalent immunogenic composition comprising 24 distinct *S. pneumoniae* polysaccharide carrier protein conjugates, wherein each of the conjugates comprises a polysaccharide of a particular *S. pneumoniae* serotype conjugated to a carrier protein, wherein the *S. pneumoniae* serotypes are 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, de-O-acetylated 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, and the carrier protein is CRM197, and wherein the composition does not comprise polysaccharide carrier protein conjugates containing polysaccharides of any other *S. pneumoniae* serotypes.

2. The multivalent immunogenic composition of claim 1, wherein the composition comprises an adjuvant.

3. The multivalent immunogenic composition of claim 2, wherein the adjuvant is an aluminum phosphate adjuvant.

4. A multivalent immunogenic composition comprising *S. pneumoniae* polysaccharide carrier protein conjugates, wherein each of the conjugates comprises a polysaccharide of a particular *S. pneumoniae* serotype conjugated to a carrier protein, wherein the *S. pneumoniae* serotypes consist of 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, de-O-acylated 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, and the carrier protein is CRM197.

5. The multivalent immunogenic composition of claim 4, wherein the composition comprises an adjuvant.

6. The multivalent immunogenic composition of claim 5, wherein the adjuvant is an aluminum phosphate adjuvant.

7. A multivalent immunogenic composition comprising *S. pneumoniae* polysaccharide carrier protein conjugates, wherein each of the conjugates comprises a polysaccharide of a particular *S. pneumoniae* serotype conjugated to a carrier protein, wherein the *S. pneumoniae* serotypes consist essentially of 1, 3, 4, 5, 6A, 6B, 7F, 8, 9V, 10A, 11A, 12F, 14, 15A, de-O-acylated 15B, 18C, 19A, 19F, 22F, 23B, 23F, 24F, 33F and 35B, and the carrier protein is CRM197.

8. The multivalent immunogenic composition of claim 7, wherein the composition comprises an adjuvant.

9. The multivalent immunogenic composition of claim 8, wherein the adjuvant is an aluminum phosphate adjuvant.

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