CLAIMS:

1. A method for preventing or treating an infection by streptococcal bacteria in a subject, the method comprising administering a therapeutically effective amount of photon-irradiated streptococcal bacteria to the subject to thereby prevent or treat the infection.

2. The method according to claim 1, wherein the method prevents or treats infection by a plurality of different streptococcal species and/or serotypes.

3. The method according to claim 2, wherein the photon-irradiated streptococcal bacteria comprise different: *Streptococcus* species, streptococcal serotypes, and/or streptococcal derivatives.

4. The method according to any one of claims 1 to 3, wherein the streptococcal infection comprises infection by one or more serotypes of *Streptococcus pneumoniae*.

5. The method according to any one of claims 1 to 4, wherein the infection by streptococcal bacteria is any one or more of a respiratory tract infection, pneumonia, an ear infection, an ear-ache, a middle ear infection, otitis media, sinusitis, meningitis, conjunctivitis, bacteraemia, septicaemia, a joint infection, a bone infection, septic arthritis, sepsis, osteomyelitis, a soft tissue infection, cellulitis, myositis, periorbital cellulitis, an abscess, necrotising fasciitis, impetigo, peritonitis, a cardiac infection, endocarditis, and/or pericarditis.

6. A method of inducing an immune response against streptococcal bacteria in a subject, the method comprising administering a therapeutically effective amount of photon-irradiated streptococcal bacteria to the subject to thereby induce the immune response.

7. The method according to claim 6, wherein the immune response comprises a heterotypic immune response against a different streptococcal species and/or serotype to that administered to the subject.

8. The method according to claim 6 or claim 7, wherein the therapeutically effective amount of photon-irradiated streptococcal bacteria comprise different: *Streptococcus* species, streptococcal serotypes, and/or streptococcal derivatives.

9. The method according to claim 7 or claim 8, wherein the different streptococcal species and/or serotype is a *Streptococcus pneumoniae* serotype.

10. The method according to any one of claims 6 to 9, wherein the immune response comprises any one or more of:

(i) a B-lymphocyte response;

(ii) an innate immune response induced at least in part by interaction of double-stranded RNA from the photon-irradiated streptococcal bacteria with Toll-like receptors;

(iii) a T-lymphocyte response.

11. The method according to any one of claims 1 to 10, wherein the photon-irradiated streptococcal bacteria comprise at least one *Streptococcus pneumoniae* serotype, or at least one unencapsulated derivative of a *Streptococcus pneumoniae* serotype.

12. The method according to any one of claims 1 to 11, wherein the photon-irradiated streptococcal bacteria comprise mutant streptococcal bacteria comprising:

(i) one or more defective DNA repair proteins; and/or

(ii) a genetic alteration causing defective DNA repair capacity.

13. The method according to claim 12, wherein the photon-irradiated mutant streptococcal bacteria comprise a defect in at least one gene that encodes a DNA repair protein.

14. The method according to claim 13, wherein the photon-irradiated mutant streptococcal bacteria are *Streptococcus pneumoniae* mutants comprising a defect in one or more genes selected from a gene encoding a DNA alkylation repair protein, a gene encoding DNA polymerase 4, *hexA*, *hexB*, *mutS*, *radC*, *recA*, *recF*, *recN*, *recO*, *uvrA*, *uvrB*, *uvrC* or *uvrD*.

15. The method according to any one of claims 12 to 14, wherein the defective DNA repair protein is mutated, truncated or absent in the photon-irradiated mutant streptococcal bacteria.

16. The method according to any one of claims 12 to 15, wherein the photon-irradiated mutant streptococcal bacteria comprise streptococcal Rx1 strain derivatives in which:

(i) any one or more of autolysin, hemolysin, pneumolysin, and/or PsaA protein is/are defective; and/or

(ii) any one or more of autolysin, hemolysin, and/or a PsaA protein is/are absent.

17. The method according to claim 16, wherein the photon-irradiated streptococcal Rx1 strain derivatives:

(i) comprise any one or more of a gene encoding a defective autolysin protein, a gene encoding defective hemolysin, a gene encoding defective pneumolysin, and/or a gene encoding defective PsaA protein; or

(ii) are derivatives in which any one or more of a gene encoding autolysin, a gene encoding hemolysin, and/or a gene encoding PsaA protein, is/are absent.

18. The method according to claim 16 or claim 17, wherein the autolysin is LytA.

19. The method according to any one of claims 16 to 18, wherein the photon-irradiated streptococcal Rx1 strain derivatives:

(i) comprise a gene encoding defective LytA protein, and a gene encoding defective pneumolysin; or

(ii) do not contain the *lytA* gene, and comprise a gene encoding a defective pneumolysin.

20. The method according to any one of claims 12 to 19, wherein the photon-irradiated mutant streptococcal bacteria require a reduced dosage of photon-irradiation for inactivation compared to that required by corresponding non-mutant streptococcal bacteria.

21. The method according to any one of claims 1 to 20, wherein some or all of the photon-irradiated streptococcal bacteria comprise modified streptococcal bacteria comprising a sequence of DNA encoding an RNA transcript, wherein the RNA transcript comprises a region of self-complementarity capable of forming a double-stranded portion after transcription.

22. The method according to claim 21, wherein the portion of the double-stranded RNA transcript is at least: 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65 or 70 base pairs in length.

23. The method according to claim 21 or claim 22, wherein the double-stranded RNA transcript initiates an innate immune response in the subject comprising Toll-like receptor activation.

24. The method according to claim 23, wherein the Toll-like receptor is Toll-like receptor-3 (TLR-3).

25. The method according to any one of claims 1 to 24, wherein the photon-irradiated streptococcal bacteria comprise auxotrophic mutant streptococcal bacteria.

26. The method according to any one of claims 1 to 24, wherein the photon-irradiated streptococcal bacteria comprise at least one recombinant DNA portion encoding an antigen or a component thereof that:

(i) inactivates or attenuates the bacteria; and/or

(ii) induces or enhances an immune response in the subject.

27. The method according to claim 26, wherein the recombinant DNA portion replaces or disrupts an endogenous gene necessary for pathogenicity, infection, multiplication, growth *in vivo*, or any combination thereof.

28. The method according to any one of claims 1 to 27, wherein the photon-irradiated streptococcal bacteria comprise whole killed streptococcal bacteria.

29. The method according to any one of claims 1 to 28, wherein the photon-irradiated streptococcal bacteria are administered to the subject mucosally or intranasally.

30. The method according to any one of claims 1 to 29, wherein the photon-irradiated streptococcal bacteria are administered to the subject in combination with an adjuvant.

31. The method according to any one of claims 1 to 30, wherein one, two or three separate doses of the photon-irradiated streptococcal bacteria are administered to the subject.

32. The method according to any one of claims 1 to 31, wherein the subject is a human.

33. The method according to any one of claims 1 to 32, wherein the photon-irradiated streptococcal bacteria are administered a total dosage of at least: 8 kilogray (kGy), 9kGy, 10kGy, 11kGy, 12kGy, 15kGy, 20kGy, 25kGy, 30 kGy, 40kGy, or 50 kGy of photon-irradiation.

34. The method according to any one of claims 1 to 33, wherein the photon-irradiated streptococcal bacteria comprise gamma-irradiated streptococcal bacteria, X-irradiated streptococcal bacteria, or a combination thereof.

35. The method according to any one of claims 1 to 33, wherein the photon-irradiated streptococcal bacteria comprise X-irradiated streptococcal bacteria.

36. The method according to any one of claims 1 to 33, wherein the photon-irradiated streptococcal bacteria comprise a combination of gamma-irradiated streptococcal bacteria and X-irradiated streptococcal bacteria.

37. The method according to claim 20 or claim 33, wherein the photon-irradiation is gamma-irradiation.

38. The method according to claim 20 or claim 33, wherein the photon-irradiation is X-irradiation.

39. The method according to claim 20 or claim 33, wherein the photon-irradiation is a combination of gamma-irradiation and X-irradiation.

40. The method according to any one of claims 1 to 39, wherein the photon-irradiated streptococcal bacteria comprise streptococcal Rx1 strain derivatives:

(i) comprise a gene encoding a defective LytA protein, a gene encoding defective pneumolysin, and a gene encoding defective PsaA protein;

(ii) comprise a gene encoding a defective LytA protein, a gene encoding defective pneumolysin, and in which a gene encoding PsaA protein is absent;

(iii) comprise a gene encoding a defective PsaA protein, a gene encoding defective pneumolysin, and in which a gene encoding LytA protein is absent; or

(iv) comprise a gene encoding defective pneumolysin, in which a gene encoding LytA protein is absent, and in which a gene encoding PsaA protein is absent.

41. A vaccine composition comprising photon-irradiated streptococcal bacteria and a pharmaceutically-acceptable excipient, diluent and/or carrier, wherein:

(i) the photon-irradiated streptococcal bacteria comprise. mutant streptococcal bacteria comprising one or more defective DNA repair proteins, and/or mutant streptococcal bacteria in which at least one type of DNA repair protein is absent; and/or

(ii) the photon-irradiated streptococcal bacteria comprise modified streptococcal bacteria comprising a sequence of DNA encoding an RNA transcript, wherein the RNA transcript comprises a region of self-complementarity capable of forming a double-stranded portion after transcription.

42. The vaccine composition according to claim 41, wherein the mutant streptococcal bacteria are *Streptococcus pneumoniae* mutants comprising a defect in one or more genes selected from. a gene encoding a DNA alkylation repair protein, a gene encoding DNA polymerase 4, *hexA*, *hexB*, *mutS*, *radC*, *recA*, *recF*, *recN*, *recO*, *uvrA*, *uvrB*, *uvrC* or *uvrD*.

43. The vaccine composition according to claim 41 or claim 42, wherein the modified streptococcal bacteria are modified *Streptococcus pneumoniae* bacteria and the portion of the double-stranded RNA transcript is at least. 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65 or 70 base pairs in length.

44. The vaccine composition according to any one of claims 41 to 43, wherein the photon-irradiated streptococcal bacteria comprise at least one recombinant DNA portion encoding an antigen or a component thereof that:

(i) inactivates or attenuates the bacteria; or

(ii) induces or enhances an immune response in the subject.

45. The vaccine composition according to claim 44, wherein the recombinant DNA portion replaces or disrupts an endogenous gene necessary for pathogenicity, infection, reproduction or any combination thereof.

46. The vaccine according to any one or more of claims 41 to 45, wherein the photon-irradiated streptococcal bacteria comprise streptococcal Rx1 strain derivative strains in which:

(i) any one or more of autolysin, hemolysin, pneumolysin, and/or PsaA protein is/are defective; and/or

(ii) any one or more of autolysin, hemolysin, and/or a PsaA protein is/are absent.

47. The vaccine according to claim 46, wherein the photon-irradiated streptococcal Rx1 strain derivatives:

(i) comprise any one or more of a gene encoding a defective autolysin protein, a gene encoding defective hemolysin, a gene encoding defective pneumolysin, and/or a gene encoding defective PsaA protein; or

(ii) are derivatives in which any one or more of a gene encoding autolysin, a gene encoding hemolysin, and/or a gene encoding PsaA protein, is/are absent.

48. The vaccine according to any one of claims 41 to 47, wherein the photon-irradiated streptococcal Rx1 strain derivatives:

(i) comprise a gene encoding defective LytA protein, and a gene encoding defective pneumolysin; or

(ii) do not contain the *lytA* gene, and comprise a gene encoding a defective pneumolysin.

49. The vaccine according to any one of claims 41 to 48, wherein the photon-irradiated mutant streptococcal bacteria comprise streptococcal Rx1 strain derivatives:

(i) comprise a gene encoding a defective LytA protein, a gene encoding defective pneumolysin, and a gene encoding defective PsaA protein;

(ii) comprise a gene encoding a defective LytA protein, a gene encoding defective pneumolysin, and in which a gene encoding PsaA protein is absent;

(iii) comprise a gene encoding a defective PsaA protein, a gene encoding defective pneumolysin, and in which a gene encoding LytA protein is absent; or

(iv) comprise a gene encoding defective pneumolysin, in which a gene encoding LytA protein is absent, and in which a gene encoding PsaA protein is absent.

50. The vaccine composition according to any one of claims 41 to 49, wherein the photon-irradiated streptococcal bacteria comprise whole-attenuated or whole-killed streptococcal bacteria.

51. The vaccine composition according to any one of claims 41 to 50, further comprising an adjuvant.

52. The vaccine composition according to any one of claims 41 to 51, wherein the vaccine composition is formulated for mucosal or intranasal administration or formulated for injection intramuscularly, subcutaneously or intradermally.

53. The vaccine composition according to any one of claims 41 to 52, wherein the photon-irradiated streptococcal bacteria comprise gamma-irradiated mutant streptococcal bacteria and/or gamma-irradiated modified streptococcal bacteria.

54. The vaccine composition according to any one of claims 41 to 52, wherein the photon-irradiated streptococcal bacteria comprise X-irradiated mutant streptococcal bacteria and/or X-irradiated modified streptococcal bacteria.

55. The vaccine composition according to any one of claims 41 to 52, wherein the photon-irradiated streptococcal bacteria comprise:

(i) a combination of gamma-irradiated and X-irradiated mutant streptococcal bacteria; and/or

(ii) a combination of gamma-irradiated and X-irradiated modified streptococcal bacteria.

56. A method for preparing the vaccine composition according to any one of claims 41 to 55, the method comprising:

(i) photon-irradiating a preparation of streptococcal bacteria to thereby attenuate or kill the bacteria; and

(ii) combining the photon-irradiated streptococcal bacteria with a pharmaceutically-acceptable excipient, diluent and/or carrier.

57. The method according to claim 56, wherein said photon-irradiating the preparation of streptococcal bacteria comprises exposing the bacteria to gamma-radiation.

58. The method according to claim 56, wherein said photon-irradiating the preparation of streptococcal bacteria comprises exposing the bacteria to X-radiation.

59. The method according to claim 56, wherein said photon-irradiating the preparation of streptococcal bacteria comprises exposing the bacteria to gamma-radiation and X-radiation.

60. A vaccine composition prepared by the method of any one of claims 56 to 59.

61. A vaccine composition according to any one of claims 41 to 55 or 60 for use in preventing or treating an infection by streptococcal bacteria.

62. Use of photon-irradiated streptococcal bacteria in the preparation of a medicament for preventing or treating an infection by streptococcal bacteria, wherein the medicament is the vaccine composition according to any one of claims 41 to 55 or 60.

63. The vaccine composition according to claim 61 or the use according to claim 62, wherein the infection by streptococcal bacteria is any one or more of a respiratory tract infection, pneumonia, ear infection, earache, middle ear infection, otitis media, sinusitis, meningitis, conjunctivitis, bacteraemia, septicaemia, a joint infection, a bone infection, septic arthritis, osteomyelitis, a soft tissue infection, cellulitis, myositis, periorbital cellulitis, an abscess, peritonitis, a cardiac infection, endocarditis, and pericarditis.