Immunization of Children with Cancer in India Treated with Chemotherapy – Consensus Guideline from the Pediatric Hematology-Oncology Chapter and the Advisory Committee on Vaccination and Immunization Practices of the Indian Academy of Pediatrics

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Justification: Children with cancer need to be immunized against the common vaccine-preventable diseases after completion and sometimes during ongoing treatment of cancer. However, the immunization schedule for these children needs to be altered due to disease and treatment related immune-suppression. Consequently, there are many guidelines/practice statements from around the world to address this issue, however, there is no such comprehensive guideline from India catering to the need of Indian children with cancer. **Process:** A guideline was drafted after reviewing the available literature. The draft guideline was discussed and modified in a meeting attended by pediatric oncologists from the PHO chapter and vaccine experts from the ACVIP of the IAP. Subsequently, the modified draft was reviewed and recommendations were finalized. **Objective:** To review the current evidence and generate a nationally relevant guideline for immunization of children receiving chemotherapy for cancer. **Recommendations:** Live vaccines are contraindicated during and up to 6 months after end of chemotherapy. Non-live vaccines are also best given after 6 months from the end of treatment for durable immunity. Annual inactivated influenza vaccine is the only vaccine recommended for all children during chemotherapy whereas hepatitis B vaccine is recommended only for previously unimmunised children with risk of transfusion associated transmission of infection. Post-treatment re-immunization/catch-up schedule largely depends on the pre-chemotherapy immunization status. Sibling immunization should continue uninterrupted except for oral polio vaccine which needs to be substituted by the injectable vaccine. Inactivated influenza vaccine is recommended and varicella vaccine is encouraged for all contacts including siblings.

Keywords: *Immunosuppression, Malignancy, Prevention, Vaccine.*

Pediatric cancers are nowadays largely curable, with very high cure rates in the developed countries and steadily improving outcomes in the developing countries [1]. Immunization for vaccine preventable diseases is important in children with cancer as it can reduce non cancer related morbidity/ mortality and contribute favourably to the overall outcome in these children. Many developed countries have formulated guidelines for vaccinating children with cancer during their treatment as well as after the completion of treatment, in line with their national immunization schedules. There was a long standing need for a similar dedicated guideline from a national body on vaccination strategies for children with cancer in India as evident in a recent survey documenting non-uniform and disparate immunization practice among pediatric oncologists in India [2]. But apart from a cursory coverage in the previous editions of the Guidebook on Immunization by Indian Academy of Pediatrics (IAP), no other document attempted to address it. In the latest edition of its guidebook (2013-14) [3], IAP has addressed this issue in a greater detail as compared to its previous editions.

Accompanying Editorial: Pages 109-10.

That said, the recommendations therein have been mostly adapted from the latest recommendations of the Infectious Disease Society of America (IDSA) clinical practice guidelines on immunization of immuno-compromised hosts published in 2013 [4], which understandably does not cover all the issues relevant to infectious diseases (and immunization practices) in Indian children. Moreover, the IDSA guidelines are not in agreement with the recommendations made by majority of similar other bodies worldwide. For example, it recommends re-immunization of children from 3 months following the end of their cancer chemotherapy, whereas

most authorities would recommend a gap of 6 months from end of treatment for long lasting and effective immunity [5-10]. Furthermore, the recommendations in the IAP guidebook (2013-14) do not cover all vaccines, including some vaccines of local importance in India, neither does it provide guidance on the number of doses of each vaccine to be given in these children depending on their immunization status. The recommendations on immunization of contacts (siblings etc.) of these children are also missing.

Therefore, there remains an unmet need for a national consensus guideline addressing immunization related issues in children with cancer and their contacts/siblings which are in line with evidence-based consensus guidelines from around the world.

PROCESS

A Pubmed and Google search was undertaken to obtain all publications on immunization of children with cancer, all the relevant literature published on related topics were reviewed including national guidelines from the Infectious Disease Society of America [4], the Royal College of Paediatrics and Child Health, United Kingdom [5] as well as various institute/group specific guidelines published from the UK [6,7], Italy [8], Canada [9], Australia [10] and some of the developing countries like South Africa (personal communication Alan Davidson, University of Cape Town, South Africa) and Pakistan [11].

A draft guideline was produced based on the evidence and practice recommendations contained in previously published literature including the current IAP guidebook 2014 [3]. This draft guideline was then circulated by email to the nominated representatives of PHO chapter and ACVIP of IAP. A meeting was then held between the relevant nominated members of both these bodies on the 9th July, 2016 at Hyderabad, India. The draft guideline was discussed and screened at that meeting and modified according to the recommendations made by the attendees. The modified version was re-circulated by email among the attendees and a final guideline was generated by the writing committee based on further inputs from the attendees. The final and updated (upon incorporation of current IAP immunization recommendations 2018 [12]) guideline was approved by PHO chapter on 26th April, 2018 and by ACVIP on 25th September, 2018.

Objectives

To review the current evidence and generate a nationally relevant guideline for immunization of children who receive chemotherapy for cancer. This guideline aims to ensure uniformity and streamline the current practice of immunising children with cancer during and after chemotherapy.

Scope of the Guideline

This guideline applies to children with cancer who have received chemotherapy. They do not apply to those who have received myeloablative chemotherapy e.g. those undergoing stem cell transplant (autologous or allogenic). They may also not be relevant to those children who only receive surgery and/or local radiotherapy for their cancer treatment *e.g.* low grade gliomas. This guideline does not cater to the needs of children treated with targeted therapy including monoclonal antibodies, small molecule targeted agents and other modalities of immunotherapy that are currently being increasingly used in the management of childhood cancers. We wish to include recommendations for the above group in the next revision of this guideline, anticipating availability of more evidence by then. This guideline does not take into account every possible scenario and the pediatrician/physician/oncologist immunizing these children has to ultimately decide what is most appropriate for a given situation. Factors guiding immunization of children with cancer during and after treatment include – immunization status prior to starting cancer treatment, current immunization schedule e.g. IAP or UIP (Universal Immunization Programme), risk of getting exposed to vaccine-preventable disease during treatment e.g. hepatitis B.

Plan of Review

The current guideline would need updating in 2 years from the date of publishing and would need interim amendments in line with change in IAP-ACVIP recommendations on vaccines.

IMPORTANCE OF IMMUNIZATION IN CHILDREN WITH CANCER

Pediatric cancers present with varying degrees of immune suppression [13,14]. This may range from minimal involvement of the immune system in children with localised solid malignancies to extensive immune suppression due to pancytopenia at presentation in acute leukemia. Some diseases present with specific immune involvement *e.g.*, Hodgkin lymphoma and Burkitts lymphoma are associated with lack of lymphocytic response to various antigens [15] and variable levels of lymphocyte depletion, respectively [16]. Despite these changes, children rarely have clinically significant immune suppression prior to initiation of cytotoxic chemotherapy [14]. The degree of immune suppression depends on the intensity, duration and nature of chemotherapeutic agents [17]. Both cellular and humoral immunity is affected due to involvement of the T-cell/

Natural killer (NK) cells and B-lymphocytes respectively [18]. The time to recovery seems to be longer for the T-cells as compared to the B-cells [18,19] and some of the immune defects may persist even longer after stoppage of chemotherapy [20]. Therefore, vaccine uptake during chemotherapy and for sometime thereafter may be erratic. Acquired immunity through previous infections or immunization also wanes due to effect of chemotherapy on immune system and needs boosting on recovery of immunity following end of chemotherapy [17]. Despite lack of consensus, most authorities recommend commencement of immunization at 6 months from the end of standard dose chemotherapy with the assumption that reasonable immunity is gained around that time [3-11].

RECOMMENDATIONS

Non-live Vaccines Recommended by IAP for Routine Use

Diptheria, Pertussis and Tetanus (DPT) vaccine [3,5]: Only DPT with whole cell pertussis component is included in UIP. TdaP and Td are not included. IAP recommended upper age limit for vaccination is 7 years. It is recommended 6 months after stoppage of chemotherapy and not during ongoing chemotherapy. The schedule comprises of three doses at 0,1 and 6 months (DwPT or DaPT if <7 years of age; TdaP 1st dose followed by given as Td 2nd and 3rd dose if > 7 years of age; TdaP only to be used beyond 7 years of age) in previously unimmunized children and a single booster dose (DwPT or DaPT if <7 years of age; TdaP if > 7 years of age) in those with previously completed immunization.

Injectable Polio Virus (IPV) vaccine [21,22]: Included in UIP as a four dose schedule. IAP recommended upper age limit for vaccination as 5 years. It is recommended 6 months after stoppage of chemotherapy and not during ongoing chemotherapy. The schedule for previously unimmunized children is two doses of IPV 2 months apart and 3rd dose after 6 months after 2nd dose whereas in previously immunised children a single booster dose of IPV is sufficient. In children with previously completed immunization with OPV, 2 doses of IPV one month apart is recommended. IPV is the preferred vaccine in these children. Fractional IPV [fIPV] can also be used for the initial 2 doses. OPV has to be given if IPV is not accessible.

Hepatitis B Vaccine (HBV): [23,24] : It is included in UIP. There is no IAP recommended upper age limit for vaccination.There is no need for further doses for children who have completed primary immunization schedule prior to diagnosis of cancer. In the current era, with improved safety of blood products [nucleic acid amplification (NAT)

TABLE I RECOMMENDATIONS FOR LIVE VACCINES

Vaccine	*During chemotherapy*	*After end of chemotherapy*	
		Previously unimmunized children	*Children with completed immunization*
BCG	Not recommended, contact vaccination not discouraged	Single dose BCG at 6 mo after completion of chemotherapy.	Not recommended in previously immunised children with visible BCG scar
OPV	Not recommended, contact vaccination contraindicated	IPV preferred, when unavailable 3 doses of bOPV 1mo apart (maximum age 5 y)	IPV preferred, when unavailable 2 doses of bOPV 1mo apart (maximum age 5 y)
MMR	Not recommended, contact vaccination not discouraged.	Two doses of MMR (1 to 3 mo apart) should be given to all children after at least 6 mo of completion of chemotherapy	Single dose of MMR should be given to all children after at least 6 mo of completion of chemotherapy
Varicella vaccine	Not recommended, contact vaccination encouraged.	2 doses of vaccine 1-3 mo apart. (after 6 mo of completing chemotherapy)	Single booster dose 6 mo after stopping chemotherapy
Live attenuated HAV	Not recommended	Single dose after 6 mo of completing chemotherapy	Single dose after 6 mo of completing chemotherapy
Rotavirus vaccine	Not recommended, contact vaccination not discouraged	Generally child outgrows the maximum permissible age, therefore not indicated.	Generally child outgrows the maximum permissible age, therefore not indicated.

BCG: Bacillus Calmette-Guerin; OPV: Oral Polio Vaccine; MMR: Mumps Measles Rubella; HAV: Hepatitis A vaccine.

TABLE II RECOMMENDATIONS FOR NON-LIVE VACCINES

Vaccine	*During chemotherapy*	*After end of chemotherapy*	
		Previously unimmunized children	*Children with completed immunization*
DPT (age appropriate preparation-DwPT/ DaPT/TdaP/Td)	Not recommended during ongoing chemotherapy	3 doses at 0,1 and 6 mo (6 mo after stopping chemotherapy)	Single booster dose (6 mo after stopping chemotherapy)
Hib	Not recommended during ongoing chemotherapy	Age >6 mo 2 doses 8 wk apart, followed by booster at 12 mo; 12-15 mo single dose followed by booster at 18 mo; 15-60 mo single dose (6 mo after stopping chemotherapy)	Single booster dose (6 mo after stopping chemotherapy)
IPV	Not recommended during ongoing chemotherapy	2 doses of IPV 2 mo apart and 3rd dose after 6 mo (6 mo after stopping chemotherapy)	Single booster dose (6 mo after stopping chemotherapy). Two doses for children who received OPV as primary immunisation
HBV	4 doses of vaccine (0,1,2 and 12 mo) at double dosage is recommended for previously unimmunized children, no further doses for children who completed primary schedule prior to diagnosis.	3 doses at 0,1 and 6 mo (6 mo after stopping chemotherapy)	Single booster dose (6 mo after stopping chemotherapy)
HAV	Not recommended during ongoing chemotherapy	2 doses 6 mo apart (6 mo after stopping chemotherapy)	Single booster dose (6 mo after stopping chemotherapy)
Inactivated Influenza Vaccine	Recommended single dose annually during chemotherapy	Not recommended routinely beyond 1 y from the end of chemotherapy	Not recommended routinely beyond 1 y from the end of chemotherapy
Pneumococcal vaccine	Not recommended during ongoing chemotherapy	(6 mo after stopping chemo-therapy) Age <1 yr: 2 doses of PCV-7/13 at 4-8 wk interval followed by a booster dose at 12-15 mo age Age 1-2 y: 2 doses of PCV-7/13, 4-8 wk apart; Age > 2y: 1 dose of PCV-7/13. PPV-23 booster is not recommended for this group of children	Single booster dose (6 mo after stopping chemotherapy)
Inactivated typhoid vaccine	Single booster dose (6 mo after stopping chemotherapy)	Single dose typhoid conjugate vaccine 6 mo after stopping chemotherapy	Single dose typhoid conjugate vaccine 6 mo after stopping chemotherapy
HPV	Not recommended during ongoing chemotherapy	Age 9-14 y - 2 doses 6 mo apart in females, age >14 y - 3 doses at 0,1 and 6 mo (HPV2) or 0,2 and 6 mo (HPV4) in females (6 mo after stopping chemotherapy).	Insufficient data on booster dose but single booster dose may be considered in females

DPT: Diphtheria pertussis tetanus; wP: whole cell pertussis; aP: acellular pertussis; HiB: Haemophilus influenza Type B; IPV: Inactivated polio vaccine; HBV: Hepatitis B vaccine; HAV: Hepatitis A vaccine; HPV: Human papilloma virus; HPV2: Bivalent HPV, HPV4: Quadrivalent HPV.

testing] as well as increasing hepatitis B immunization, active and passive immunization for hepatitis B is generally not recommended during treatment. If, however, there is risk of suboptimal blood transfusion practices in a child diagnosed with cancer who is unimmunized and who is hepatitis B surface antigen negative, then it is recommended to administer 4 doses of vaccine at 0, 1, 2 and 12 months at double dosage as well as age appropriate

dose of hepatitis B immunoglobulin every 3 months till there is no risk of exposure to blood products. HBV vaccine is recommended 6 months after stoppage of chemotherapy as 3 doses at 0, 1 and 6 months in previously unimmunized children and a single booster dose in children with previously completed immunization.

Hemophilus influenzae Type B Conjugate vaccine (HiB) [25]: Hib vaccine is included in UIP in some states. IAP has recommended upper age limit for vaccination as 5 years. It is not recommended during ongoing chemotherapy. It is recommended 6 months after stoppage of chemotherapy as a single booster dose in children with previously completed immunization. In previously unimmunized children the schedule is age dependent (age 6-12 months - two doses 8 week apart, followed by booster at 12 months; age 12-15 months - one dose and booster at 18 months; age 15-60 months - one dose).

Pneumococcal vaccine [25]: Pneumococcal vaccines are not included in UIP. Pneumococcal conjugate vaccine (PCV) is recommended for routine use by IAP. Pneumococcal polysaccharide vaccine (PPSV) is only recommended for high-risk population. IAP recommended upper age limit for vaccination as 5 years. Pneumococcal vaccines are not recommended during chemotherapy. Recommended schedule at 6 months after stoppage of chemotherapy is age dependent for previously unimmunized children (age <1 yr: 2 doses of PCV at 4-8 week interval followed by a booster dose between 12-15 months age; age 1-2 years: 2 doses of PCV 8 weeks apart; age 2-5 yrs: single dose of PCV). In children with previously completed immunization single booster dose of PCV is recommended. PPSV is not recommended in children with cancer undergoing standard dose chemotherapy.

Inactivated Hepatitis A vaccine [5,26]: Hepatitis A vaccines are not included in UIP. There is no IAP recommended upper age limit for vaccination. It is recommended 6 months after stoppage of chemotherapy and not during ongoing chemotherapy. Recommended schedule in previously unimmunized children comprises of two doses 6 months apart. In children with previously completed immunization, single booster dose is adequate.

Typhoid vaccine [11,25]: It is not included in UIP. There is no IAP recommended upper age limit for vaccination. It is recommended 6 months after stoppage of chemotherapy and not during ongoing chemotherapy. The recommended schedule includes a single dose of typhoid conjugate vaccine for both previously immunised as well as unimmunized children. No booster doses are recommended as of now.

Human Papilloma Virus Vaccine [3, 27]: It is not included in UIP. IAP recommended upper age limit for vaccination is 45 years. It is recommended 6 months after stoppage of chemotherapy and not during ongoing chemotherapy. The schedule in previously unimmunized girls are age dependent [age 9-14 years - two doses 6 months apart in females, age > 14 years – three doses at 0,1 and 6 months (bivalent HPV), or 0, 2 and 6 months quadrivalent (HPV) in females]. HPV vaccines are not licensed for use in male children in India. In children with previously completed immunization there is no data to make any recommendation but single dose may be considered in females.

Live Vaccines Recommended by IAP for Routine Use

Bacillus Calmette Guerin (BCG) vaccine [25,28]: BCG vaccine is included in UIP. IAP recommended upper age limit for vaccination is 5 years. It is contraindicated during ongoing chemotherapy and can only be given after 6 months of completion of chemotherapy as a single dose in previously unimmunized children. In children with previously completed immunization with visible scar no further doses are recommended.

Oral Polio Virus vaccine (OPV) [25,28]: OPV is included in UIP. IAP recommended upper age limit for vaccination is 5 years. It is contraindicated during and upto 6 months after chemotherapy including pulse polio immunization days. After 6 months from stoppage of chemotherapy it is recommended to vaccinate children with IPV (see under IPV). When IPV is unavailable bivalent OPV (bOPV), three doses 1 month apart is recommended for unimmunized children. In children with previously completed immunization two doses of bOPV, 1 month apart is recommended if IPV is unavailable. After 6 months of stopping treatment children should be actively encouraged for pulse polio immunisation days.

Measles, Mumps and Rubella (MMR) vaccine [25, 29]: MMR or MR (measles and rubella) is included in UIP. There is no IAP recommended upper age limit for vaccination. MMR vaccine is contraindicated during and up to 6 months after chemotherapy. Ribavirin and intravenous immunoglobulin (IVIg) have been tried for post-exposure prophylaxis of measles during chemotherapy. Recommendation after 6 months of stoppage of chemotherapy in previously unimmunized children is two doses 1 to 3 months apart, whereas single dose is recommended for previously immunized children.

Varicella vaccine [25,8]: Not included in UIP. There is no IAP recommended upper age limit for vaccination. Vaccination with varicella vaccine is contraindicated

during ongoing chemotherapy and 6 months thereafter. Following which the schedule is age dependent in unimmunized children (<13 years age - two doses of vaccine >3 months apart, >13 years age - two doses of vaccine >1 months apart) whereas single booster dose is recommended in children with previously completed immunization. Vaccination is not needed in children with history of chicken-pox prior to treatment. Children exposed to varicella infection during ongoing chemotherapy should be given prophylaxis with Varicella Zoster Immunoglobulin (VZIg)/IVIg or oral acyclovir.

Live Attenuated Hepatitis A Vaccine [25]: It is not included in UIP and there is no IAP recommended upper age limit for vaccination. It is contraindicated during ongoing chemotherapy. A single dose for both previously immunized and unimmunized children is recommended after 6 months from stoppage of chemotherapy.

Rotavirus Vaccine [30]: Rotavirus vaccine is not included in UIP. IAP recommended upper age limit for vaccination is 12 months of age. It is contraindicated during ongoing chemotherapy. Generally child outgrows the maximum permissible age for vaccination by 6 months after end of chemotherapy therefore rotavirus vaccine is not indicated.

Live and Non-Live Vaccines Recommended by IAP for High-Risk Children

Influenza vaccine (inactivated) [31-33]: Influenza vaccine is not included in UIP and there is no IAP recommended upper age limit for vaccination. Recommendation during ongoing chemotherapy and up to 1 year after completion of treatment is age dependent (age 6 months to 9 years – two doses one month apart and then single dose every year till indicated, age >9 years – single dose every year till indicated). Vaccination should start as soon as the new vaccine is released and available in the market. The recommended period is just before the onset of the rainy season (before June for most of India and before October for some of the southern states).

After 1 year from the completion of chemotherapy, influenza vaccine is not recommended routinely unless the child continues to have high-risk conditions necessitating influenza vaccination *e.g.,* chronic cardiac, pulmonary, liver and renal disease, diabetes, HIV, etc.

Rabies vaccine (post exposure prophylaxis) [25]: Children with cancer undergoing treatment may mount a significantly lower or no detectable neutralizing antibody response to rabies. In such patients in whom the presence of immunological memory is no longer assured as a result of other causes, proper and thorough wound management and antisepsis accompanied by local infiltration of rabies immunoglobulin followed by anti-rabies vaccination are of utmost importance. Even immunocompromised patients with category II exposures should receive rabies immunoglobulin in addition to a full post-exposure vaccination including the 6th dose on day 90 which is also mandatory.

Tetanus prophylaxis in wound management [25]: All patients presenting with skin wounds/ infections should be evaluated for tetanus prophylaxis. Cleaning of the wound, removal of devitalized tissue, irrigation and drainage is important to prevent anaerobic environment which is conducive to tetanus toxin production.

In a child with cancer who is on treatment and who then gets a wound, it can be assumed that the antibody levels are inadequate. Therefore in a clean, minor wound – Td/TdaP booster regardless of immunization status is recommended, for all other wounds – Td/TdaP + Tetanus Immuno Globulin is advised.

Varicella post-exposure prophylaxis [34]: Children exposed to varicella infection during ongoing chemotherapy should be given prophylaxis with VZIg/ IVIg and/or oral acyclovir. Under ideal circumstances VZV IgG levels should be assessed at the time of exposure and children with less than protective levels, varicella zoster immunoglobulin (VZIg) should be offered (Dose 0-5 years 250 mg, 6-10 years 500 mg, 11-14 years 750 mg, ≥15 years 1000 mg given by slow intramuscular injection). Alternatively, human normal immunoglobulin at 0.2g/kg can be given intravenously, in case both the above are unaffordable high dose oral acyclovir prophylaxis (age <2 years 200 mg QID, 2-6 years 400 mg QID, >6 years 800 mg QID) has to be started from day 7 and continued till day 21 from the time of exposure.

Other vaccines: Other non-live vaccines like Meningococcal vaccine, Japanese encephalitis vaccine, Cholera vaccine and Yellow fever vaccine are not recommended by IAP for routine use in healthy children. They also have no specific role in children with cancer during or after treatment. It is recommended to consult the IAP guide book of immunization to decide whether or not to use these vaccines in specific situations.

Immunization in asplenia/hyposplenia [8,25,28]: In childhood cancer patients, asplenia or hyposplenia may result from radiation therapy involving spleen. Occasionally splenectomy may be part of local control of cancer. These children are at a high risk of serious infection with encapsulated organisms. In addition to routine vaccines, immunization with pneumococcal (both conjugate and polysaccharide), *hemophilus influenzae*

type B, meningococcal and typhoid vaccines are indicated.

If splenectomy is planned, immunization should be initiated at least 2 weeks prior to splenectomy to achieve a superior immunologic response.

Immunization of Contacts of Children with Cancer

Siblings [4,11,23,35]: All non-live vaccines are allowed as per immunisation schedule. Additionally inactivated influenza vaccine is recommended for the siblings. Live vaccines like BCG, MMR, Varicella, Rotavirus and Yellow fever vaccine are also allowed as scheduled. Oral polio virus vaccine is contraindicated including pulse polio immunization days. Sibling should receive IPV and if either is given by mistake or given because of lack of option, then the sibling should remain away from index child for at least 2 weeks.

Varicella vaccine is encouraged in the unimmunized sibling who has not had chicken-pox before and if the sibling develops varicella vaccine induced rash, then the sibling should stay away from index child till all lesions crust.

Rotavirus vaccine is not discouraged but immunocompromised contact (child with cancer) should refrain from changing diapers of the vaccinated infant till 4 weeks from day of vaccination.

Parents [11]: Inactivated Influenza vaccine is strongly recommended varicella vaccine is also encouraged in the unimmunized parent who has not had chicken-pox before and if the parent develops varicella vaccine induced rash, then the parent should stay away from index child.

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REFERENCES

1. Craft AW. Childhood cancer – mainly curable so where next? Acta Paediatr. 2000;89:386-92.
2. Arora RS, Prabha S, Moulik NR, Bagai P. A survey of immunization practices in children with cancer in India. Pediatr Hematol Oncol J. 2016;1:2-5.
3. Chowdhury P, Vashishtha VM. Immunization in special situations: *In*: IAP Guidebook on immunization [2013-14] – By Advisory Committee on Vaccines and Immunization Practices [ACVIP], Indian Academy of Pediatrics. National Publishing House, Indian Academy of Pediatrics, Gwalior. 2014; 365-84.
4. Rubin LG, Levin MJ, Ljungman P, Davies EG, Avery R, Tomblyn M, *et al*. 2013 IDSA clinical practice guideline for vaccination of the immunocompromised host. Clin Infect Dis. 2014;58:309-18.
5. Royal College of Paediatrics and Child Health [RCPCH]. Immunization of the immunocompromised child—Best practice statement. United Kingdom: RCPCH; 2002:10-3.
6. Patel SR, Chisholm JC, Heath PT. Vaccinations in children treated with standard-dose cancer therapy or hematopoietic stem cell transplantation. Pediatr Clin North Am. 2008;55:169-86.
7. Patel SR, Ortín M, Cohen BJ, Borrow R, Irving D, Sheldon J, *et al*. Revaccination of children after completion of standard chemotherapy for acute leukemia. Clin Infect Dis. 2007;44:635-42.
8. Cesaro S, Giacchino M, Fioredda F, Barone A, Battisti L, Bezzio S, *et al*. Guidelines on vaccinations in paediatric haematology and oncology patients. Biomed Res Int. 2014;2014:707691.
9. Allen UD. Immunizations for children with cancer. Pediatr Blood Cancer. 2007;49:1102-8.
10. The Australian Immunization handbook, 10th Edition. 2013: 148-57. Available from: *http: immunise.health.gov.au/internet/immunise/publishing.nsf/Content/7B28E87511E08905CA257D4D001DB1F8/$File/Aus-Imm-Handbook.pdf*. Accessed June 10, 2019
11. Naqvi A, Fadoo Z, Alvi S. Vaccination guidelines for children with cancer and hematopoietic stem cell transplantation living in resource-poor countries. Pediatr Blood Cancer. 2010;54:3-7.
12. Balasubramanian S, Shah A, Pemde HK, Chatterjee P, Shivananda S, Guduru VK, Soans S, Shastri D, Kumar R; IAP Advisory Committee on Vaccines and Immunization Practices, 2018-19. Indian Academy of Pediatrics (IAP) Advisory Committee on Vaccines and Immunization Practices (ACVIP) Recommended Immunization Schedule (2018-19) and Update on Immunization for Children Aged 0 Through 18 Years. Indian Pediatr. 2018;55:1066-74.
13. Martín Ibáñez I, Arce Casas A, Cruz Martínez O, Estella Aguado J, Martín Mateos MA. Humoral immunity in pediatric patients with acute lymphoblastic leukaemia. Allergol Immunopathol (Madr). 2003;31:303-10.
14. Hersh EM, Whitecar JP, McCredie KB, Bodey GP Sr, Freireich EJ. Chemotherapy, immunocompetence, immunosuppression and prognosis in acute leukemia. N Engl J Med. 1971;285:1211-16.
15. Fuks Z, Strober S, Bobrove AM, Sasazuki T, McMichael A, Kaplan HS. Long term effects of radiation of T and B lymphocytes in peripheral blood of patients with Hodgkin's disease. J Clin Invest. 1976;58:803-14.
16. Magrath IT, Simon RM. Immunosuppression in Burkitt's lymphoma. II. Peripheral blood lymphocyte populations related to clinical status. Int J Cancer. 1976;18:399-408.
17. Shetty AK, Winter MA. Immunization of children receiving immunosuppressive therapy for cancer or hematopoietic stem cell transplantation. Ochsner J. 2012;12:228-43.
18. Mackall CL. T-cell immunodeficiency following cytotoxic antineoplastic therapy: A review. Oncologist. 1999;

4:370-8.
19. Nilsson A, De Milito A, Engström P, Nordin M, Narita M, Grillner L, *et al*. Current chemotherapy protocols for childhood acute lymphoblastic leukemia induce loss of humoral immunity to viral vaccination antigens. Pediatrics. 2002;109:e91.
20. Leung W, Neale G, Behm F, Iyengar R, Finkelstein D, Kastan MB, PuiCH. Deficient innate immunity, thymopoiesis, and gene expression response to radiation in survivors of childhood acute lymphoblastic leukemia. Cancer Epidemiol. 2010;34:303-8.
21. Zignol M, Peracchi M, Tridello G, Pillon M, Fregonese F, D'Elia R. Assessment of humoral immunity to poliomyelitis, tetanus, hepatitis B, measles, rubella, and mumps in children after chemotherapy. Cancer. 2004;101:635-41.
22. Stenvik M, Hovi L, Siimes MA, Roivainen M, Hovi T. Antipolio prophylaxis of immunocompromised children during a nationwide oral poliovaccine campaign. Pediatr Infect Dis J. 1987;6:1106-10.
23. Katewa S, Sachdeva A. Vaccination in immunocompromised children. *In:* IAP Textbook of Vaccines, 1st Edition, New Delhi Jaypee Brothers, New Delhi, 2014:507-15.
24. Ghosh N, Mannan MA, Monjur F, Rizwan F, Salim AF. Escalated regimen of hepatitis B vaccine in childhood hematological malignancies while on chemotherapy. Southeast Asian J Trop Med Public Health. 2010;41: 555-61.
25. Indian Academy of Pediatrics Committee on Immunization [IAPCOI]. Consensus recommendations on immunization and IAP immunization timetable 2012. Indian Pediatr. 2012;49:549-64.
26. Verma R, Khanna P. Hepatitis A vaccine should receive priority in National Immunization Schedule in India. Hum Vaccin Immunother. 2012;8:1132-4.
27. Palefsky JM, Gillison ML, Strickler HD. Chapter 16: HPV vaccines in immunocompromised women and men. Vaccine. 2006;24:S3/140-6.
28. Succi RC, Farhat CK. Vaccination in special situations. J Pediatr [Rio J] 2006; 82:S91-100.
29. Zengin E, Sarper N. Humoral immunity to diphtheria, tetanus, measles, and hemophilus influenzae type b in children with acute lymphoblastic leukemia and response to re-vaccination. Pediatr Blood Cancer. 2009;53:967-72.
30. Lee PI, Chen PY, Huang YC, Lee CY, Lu CY, Chang MH, *et al*. Recommendations for rotavirus vaccine. Pediatr Neonatol. 2013;54:355-9.
31. Mavinkurve-Groothuis AM, van der Flier M, Stelma F, van Leer-Buter C, Preijers FW, Hoogerbrugge PM. Absolute lymphocyte count predicts the response to new influenza virus H1N1 vaccination in pediatric cancer patients. Clin Vaccine Immunol. 2013; 20:118-21.
32. Sung L, Heurter H, Zokvic KM, Ford-Jones EL, Weitzman SS, Freeman R, *et al*. Practical vaccination guidelines for children with cancer. Paediatr Child Health. 2001;6:379-83.
33. Shahin K, Lina B, Billaud G, Pedone C, Faure-Conter C. Successful H1N1 influenza vaccination of children receiving chemotherapy for solid tumors. J Pediatr Hematol Oncol. 2012;34:e228-31.
34. Bate J, Chisholm J, Heath PT, Breuer J, Skinner R, Manley S et al. PEPtalk: postexposure prophylaxis against varicella in children with cancer. Arch Dis Child. 2011; 96:841-5.
35. Shahmahmoodi S, Mamishi S, Aghamohammadi A, Aghazadeh N, Tabatabaie H, Gooya MM, *et al*. Vaccine-associated paralytic poliomyelitis in immunodeficient.

ANNEXURE I: PARTICIPANTS OF THE MEETING

Guideline committee: Nirmalya Roy Moulik, Piali Mondal, Jagdish Chandra, Ramandeep Singh Arora; *PHO-IAP representatives:* Shweta Bansal, Nitin Shah; *ACVIP-IAP representatives:* Pramod Jog, S Sanjay