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REVIEW

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Prevention of herpes zoster in acquired immunocompromised conditions: Review of updates and perspectives from Hong Kong

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ABSTRACT

Patients with acquired immunocompromising conditions face considerable risk of developing herpes zoster (HZ). Based on the underlying medical conditions and degree of immune dysfunction, these patients require tailored strategies for HZ prevention. In Hong Kong, there is currently a lack of guidelines addressing the unique needs of this vulnerable population, including the use of prophylactic measures such as antivirals and vaccines. An expert panel comprising clinical immunologists, nephrologists, infectious diseases specialists, rheumatologists, hematologists and oncologists in Hong Kong met to review current literature and international guidelines to propose a locally adapted decision-making framework for HZ prophylaxis, in patients with acquired immunocompromised conditions. This article summarizes the consensus and presents a guiding criteria for clinicians to navigate the complexities associated with HZ prevention, in the context of acquired immunodeficiency.

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Introduction

Herpes zoster (HZ; also known as shingles) is caused by reactivation of latent varicella zoster virus (VZV) and manifests as a painful dermatomal rash.[1] The global burden of HZ is substantial, with an estimated one in three individuals expected to develop HZ in their lifetime.[1] An individual's risk of HZ largely depends on cell-mediated immunity (CMI) against VZV, which is frequently attenuated among immunocompromised (IC) individuals.[1,2] Adults with immunocompromising conditions are therefore at a substantially higher risk of HZ and its subsequent complications. For instance, IC subjects had a 51% higher risk of HZ, 25% higher HZ recurrence, and 2.4-fold increased likelihood of HZ complications over immunocompetent subjects in a large-scale study of 4 million subjects from a Spanish healthcare database.[3]

In Hong Kong, the extent of HZ among IC patients is corroborated by published epidemiological evidence. Seroepidemiological data have revealed over 80% of adults possess antibodies against VZV and the lifetime risk of HZ in the general population without vaccination was projected at 28.4%.[4,5] Among the IC population, these numbers are likely higher due to the underlying conditions and immunosuppressive therapies.[6]

Moreover, susceptibility of IC individuals in Hong Kong to HZ-associated complications substantially varies according to the individual's underlying immune disease.[7] The definition of an "IC state" in the International Classification of Diseases, 10th edition (ICD-10), encompasses a wide array of clinical conditions such as hematological malignancies, solid organ neoplasms, transplants, autoimmune diseases, renal diseases (specifically, stage 5 chronic kidney disease [CKD] and end-stage renal disease [ESRD]) and human immunodeficiency virus (HIV) infection.[8]

Given the long list of acquired immunocompromising conditions, IC patients with increased risk of HZ are highly prevalent across different medical disciplines and specialties (Figure 1).[9–17] This increased risk could be due to the underlying diseases themselves, or their therapeutic interventions. The risk of HZ is highest in lung cancer within oncology diseases, but it is lower than myeloma and lymphoma. The risk is also high in patients with a history of hematopoietic stem cell transplant (HSCT) or with CKD on concomitant immunosuppressive therapy. A recent local study revealed that rheumatoid arthritis (RA) patients treated with Janus kinase inhibitors (JAKi) had a higher HZ incidence vs. those treated with tumor necrosis factor inhibitors (TNFi) (3.49 vs. 0.94 per 100 patient-years; $p < .001$).[18]

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Given that IC patients are more prone to developing HZ, their burden of disease is also expected to be higher. In a local economic analysis, IC patients had 2.5 times longer hospital stay duration and a 2.4-fold higher total direct medical cost per case than immunocompetent counterparts.[19] In the United Kingdom, the IC cohort experienced higher rates of HZ complications such as post-herpetic neuralgia (10.7% vs. 9.1%).[20] HZ is therefore a public health issue with substantial healthcare resource utilization.

Although HZ poses substantial burden among IC patients, current international guidelines on HZ prevention are variable for this patient population. Recommendations can vary by the underlying disease leading to the IC state, which complicates clinical judgment. In Hong Kong, there are currently two licensed vaccines against HZ: the non-live, Recombinant Zoster Vaccine (RZV), and the Zoster Vaccine Live (ZVL). Both vaccines are indicated for HZ prevention in adults aged ≥ 50, but only RZV is indicated for HZ prevention in those aged ≥ 18 at an increased risk of HZ due to immunodeficiency or immunosuppression caused by disease or therapy.[4,21] However, formal guidance around HZ prevention is lacking locally. Specifically, the Scientific Committee on Vaccine Preventable Diseases (SCVPD) have not made any formal recommendations regarding the use of HZ vaccines in adults and these vaccines are not included in any national vaccination programs; individuals keen on HZ vaccination will have to consult their physician for advice.[22,23] To aid clinical decision-making, an accessible summary of global HZ prevention recommendations, consolidated across different immunocompromising disease areas, would be of interest to local clinical practitioners.

This article aims to explore HZ prevention in the IC population in Hong Kong, particularly around adapting global recommendations to local practice.

Materials and methods

To evaluate real-world, evidence-based HZ prophylaxis strategies in IC populations, we conducted a literature review. Guidelines published between 2019 and 2023, with topics related to acquired IC conditions at increased risk of HZ as reviewed in Figure 1, were included. Examples include hematological malignancies, solid tumor cancers, organ transplant, HSCT, renal diseases, autoimmune diseases, RA, psoriasis, psoriatic arthritis, systemic lupus erythematosus, and HIV.

Recommendations from medical organizations such as the Asia-Pacific League of Associations for Rheumatology (APLAR), European Alliance of Associations for Rheumatology (EULAR), Kidney Disease: Improving Global Outcomes (KDIGO), American Society of Clinical Oncology (ASCO), and certain national guidelines were included. Exclusion criteria include studies on varicella (chickenpox) vaccines and past versions of recommendations from the same institute or organization.

Over 50 sources of recommendations were included for analysis. A compilation of 18 major guidelines for six IC disease areas is presented in Table S1. Recommendations are organized according to the "Who (Recipient), When (Timing), How (Strategy)" framework for specifying treatment intent. Although the IC disease area was of primary interest, age stratification was also noted for a more complete definition of sub-populations.

To implement international guidelines in local practice, eight experts across six specialties including immunology, infectious disease, rheumatology, nephrology, hematology, and oncology met on 11th September 2023 in Hong Kong, to discuss HZ prevention in the IC population and associated practical considerations. Existing recommendations were critically evaluated for entries applicable to the local setting, whilst supplementing for inadequacies under the "Who, When, How" framework of HZ prophylaxis. The results of the discussion are summarized here.

Results

Notable outcomes of clinical research

Antiviral prophylactic medications and vaccinations are critical tools in preventing HZ in IC patients, as outlined in Table 1.[24] Despite their distinct mechanisms of action, both offer substantial protection against the virus in this vulnerable population.[25–28] It is important to note that breakthrough HZ could still occur while patients are on antiviral prophylaxis, which can sometimes be attributed to viral resistance.[29,30] Despite this, their role in HZ prevention remains valuable to a comprehensive care strategy for IC patients.

When used as prophylaxis in the IC population, antivirals reduce the risk of HZ.[27] In autologous HSCT recipients, 1-month acyclovir or valacyclovir prophylaxis resulted in a higher HZ risk (aHR = 3.8; 95% CI: 2.4–5.9; $p < .001$) compared with those who had received prophylaxis for 1 year or longer.[29] Despite this, 8.2% of autologous HSCT patients on ≥1 year prophylaxis still developed HZ.[29] In a systematic review of 17 HSCT studies, protection against HZ usually waned 2 years following antiviral discontinuation, regardless of prophylactic duration.[24] For other hematological conditions such as acute promyelocytic leukemia, chronic lymphocytic leukemia, and multiple myeloma, antiviral prophylaxis also reduced the incidence and risk of HZ.[31]

Research into HZ vaccination initially focused on developing a live, attenuated vaccine to elicit CMI responses against a broad range of viral antigens, which resulted in the ZVL.[26] However, its practical use in the IC population was limited due to the risk of vaccine-associated infections.[28] In a meta-analysis of six randomized controlled trials (RCTs), vaccine efficacy of ZVL also stalled at approximately 38% in the IC population.[28] While the long-term ZVL efficacy is not known in the IC population, efficacy further declines markedly by 6–8 years post-vaccination in healthy individuals.[26] Subsequently, RZV was introduced locally in 2020 to address the specific needs of adults at increased risk of HZ.[21,32] RZV is based on the VZV glycoprotein E (gE) antigen and includes the AS01B adjuvant system to enhance immune response.[26] It thus stimulates a robust CMI response without using a live virus, offering an alternative for those contraindicated for ZVL.[26]

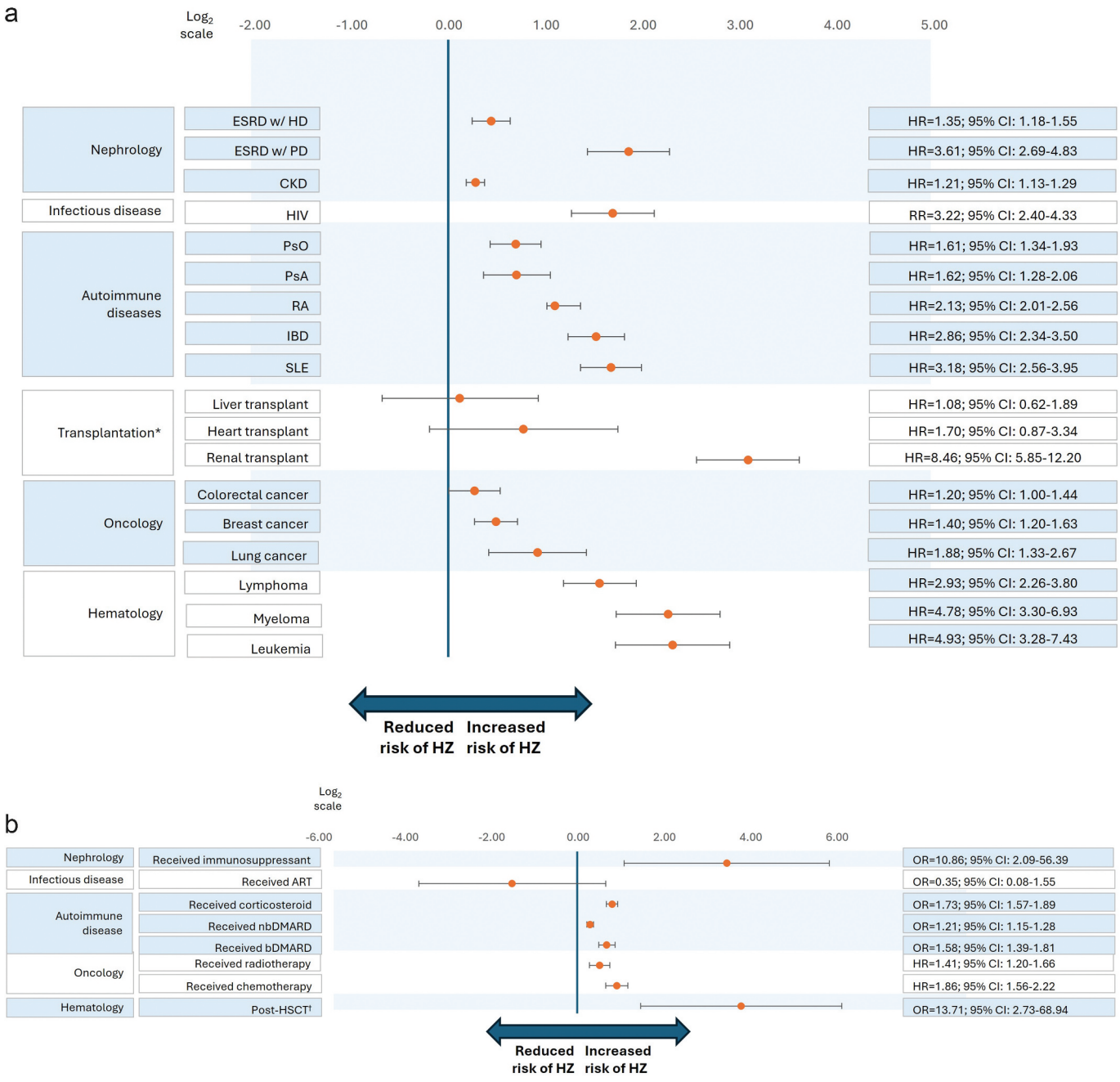

Figure 1. Risk of HZ in IC population by (a) Disease area alone vs healthy individuals, or (b) With therapy corresponding to the disease vs untreated individuals.[9–17] *The HRs of heart or liver transplants were relative to the population that received renal transplant within the same study.[12] †The type of HSCT was not specified.[10] Abbreviations: ART: Antiretroviral Therapy; (n)bDMARD: (non-)biological Disease-Modifying Anti-Rheumatic Drug; CI: Confidence Interval; CKD: Chronic Kidney Disease; ESRD: End-Stage Renal Disease; HIV: Human Immunodeficiency Virus; HD: Hemodialysis; HSCT: Hematopoietic Stem Cell Transplant; HR: Hazard Ratio; HZ: Herpes Zoster; IBD: inflammatory bowel disease; IC: Immunocompromised; OR: Odds Ratio; PD: Peritoneal Dialysis; PsA: Psoriatic Arthritis; PsO: Psoriasis; RA: Rheumatoid Arthritis; RR: Risk Ratio; SLE: Systemic Lupus Erythematosus.

In the same meta-analysis, RZV demonstrated improved clinical outcomes over ZVL.[28] In the IC population, six RCTs reported RZV vaccine efficacy of 60% vs. placebo (95% confidence interval [CI]: 49–69%).[28] Likewise, RZV demonstrated 65% vaccine effectiveness (95% CI: 57–72%) by comparison of incidence rates among eight real-world cohort studies.[28] RZV's performance in the IC group was inferior to that in the immunocompetent group (94% efficacy and 70% effectiveness, vs. placebo), but this was expected due to the inherent suppressed immune status of IC individuals.[28]

In terms of the safety of RZV, there was no statistical difference in risk of injection site reactions or systemic adverse events (AEs) between IC and immunocompetent groups; injection site reactions were generally mild-to-moderate.[28] There is a lack of data on Guillain-Barré syndrome (GBS) following RZV in the IC population specifically, but studies using United States data suggest the risk is low in the general or immunocompetent older adult population. A cohort study of the United States Medicare claims data from patients aged ≥ 65 reported that RZV vaccinees had increased risk of GBS (rate

Table 1. Evidence of HZ prophylaxis in selected IC populations.

Antiviral prophylaxis[29]	
Population	Autologous HSCT recipients
Intervention	Acyclovir or valacyclovir ≥1 year vs. 1 month*
Benefits	Reduced risk of HZ by 74%**
Risk	Breakthrough cases during and shortly (~2 years) after prophylaxis,[24] possibly due to antiviral resistance[30]
Vaccination[28]	
Population	Adults with IC diseases as defined by meta-analyses
Intervention	RZV vs. ZVL*** throughout RCT & cohort studies
Benefits	Relative effectiveness: 45% (95% CI: 30%-59%)
Risk	Serious AE: Risk ratio of 1.00 (RZV) and 1.01 (ZVL) compared to placebo

*According to Erard et al., the cohort receiving 1 month prophylaxis was given acyclovir 250 mg/m^2 twice daily. The cohorts receiving ≥1 year prophylaxis was given acyclovir 250 mg/m^2 intravenously, followed by 800 mg orally or valacyclovir 500 mg orally; all drugs were given twice daily.[29]
**aHR of HZ in patients who had no long-term prophylaxis vs. those with long-term prophylaxis is 3.8 (95% CI: 2.4–5.9; $p < .001$).
***In Hong Kong, ZVL is contraindicated in individuals who are immunodeficient or immunosuppressed due to disease or therapy. Causes include but are not limited to leukemia, lymphoma, malignant neoplasms affecting bone marrow or lymphatic system, AIDS, cellular immune deficiencies, and immunosuppressive therapy.[33]
Abbreviations: AE: Adverse Event; CI: confidence interval; HSCT: Hematopoietic Stem Cell Transplant; RZV: Recombinant Zoster Vaccine; ZVL: Zoster Vaccine Live.

ratio: 2.34; 95% CI: 1.01–5.41; $p = .047$) but further self-controlled analyses only identified an attributable risk of 3 cases per million RZV doses (95% CI: 0.62–5.64).[34] Another study of United States Vaccine Safety Datalink medical records in the general population aged ≥ 50 observed a low rate of GBS (0.09 per 10,000 doses of RZV), but concluded there were too few incident cases to draw conclusions.[35] A separate modeling study incorporating these data estimated 3–6 additional cases of GBS per one million immunocompetent adults aged ≥ 50 vaccinated with RZV, per 10-year age cohort, compared to no vaccination.[36] Generally, RZV had an acceptable safety profile for the IC population.[28] When combined with antiviral prophylaxis (for less than 60 days) in autologous HSCT recipients, around 72% vaccine effectiveness could be sustained, and therefore a dual prophylactic approach might confer additional protection.[37]

In particular, RZV prophylaxis has demonstrated efficacy in multiple IC conditions. Compared to placebo, HZ incidence was reduced in RZV-immunized autologous HSCT recipients (incidence rate ratio [IRR]: 0.32, 95% CI: 0.22–0.44; $p < .001$), and vaccine efficacy was reported to be 68.2% (95% CI: 55.6–77.5%).[37] RZV efficacy was also separately reported in patients with hematological malignancies (87.2%; 95% CI: 44.3–98.6%) and potential immune-mediated diseases (pIMD, 90.5%; 95% CI: 73.5–97.5%).[38,39] RZV also induced immunogenicity across major IC categories. Compared to placebo, sustained humoral and cell-mediated responses were observed in RZV-immunized patients with autologous HSCT (for 24 months), hematological malignancies (for 13 months), solid tumors (for 1 year), renal transplant (for 1 year) and HIV (for 18 months).[37,39–42] Post-vaccine anti-VZV antibody levels were also significantly increased among RA patients receiving JAKi or biologic disease-modifying anti-rheumatic drugs (bDMARDs).[43,44] Additionally, the safety profile for RZV was comparable to the control group for individual IC conditions. For example, the incidence of serious AEs was similar to placebo in conditions such as autologous HSCT, hematological malignancies, solid tumors, renal transplant and pIMD.[37–41] In a study of HIV patients, vaccine-related serious AEs were even reported to be absent.[42] In summary, there is overwhelming literature evidence to support the favorable risk-benefit balance of HZ prophylaxis with RZV in IC populations.

Translating research to local clinical practice

Among major guidelines described in Table S1, the approach to HZ prophylaxis, including antiviral prophylaxis and vaccination strategies, remains diverse. In this section, we provide an overview of recommendations for HZ prophylaxis across these major guidelines, grouped by disease area.

Firstly, regarding recipient and strategy, antiviral prophylaxis was adopted for hematologic conditions such as HSCT, while vaccinations were endorsed across disciplines. Of note, ZVL was rarely recommended except for autoimmune diseases. This might be because ZVL is no longer available in countries such as US and New Zealand, or is contraindicated for use in particular IC conditions such as renal diseases.[45–47] As for timing of prophylaxis, both antivirals and vaccines were commonly administered when the patient's immune response is likely to be most robust.

In hematology, the US Advisory Committee on Immunization Practices (ACIP) and Centers for Disease Control and Prevention (CDC) recommended RZV vaccination starting from 3 or 6 months post-transplant for autologous and allogenic HSCT recipients respectively.[45,48] Vaccination would preferably overlap with antiviral prophylaxis, initiating at least 2 months before its discontinuation.[45,48]

In oncology, the US National Comprehensive Cancer Network (NCCN) recommended antiviral prophylaxis for major categories of leukemia, lymphoma, and myeloma, whereas ASCO supported RZV vaccination for all cancer types.[49,50] Meanwhile, Associazione Italiana di Oncologia Medica (AIOM) suggested RZV vaccination for cancer survivors, polycormobid patients and chemotherapy recipients.[51,52] Vaccination was preferably scheduled 2–3 weeks before the start of cancer treatments.[51]

In nephrology, RZV vaccination was preferred for CKD patients by three organizations.[46,47,53] In solid organ transplantation, the American Society of Transplantation (AST) recommended selective treatment by case: acyclovir or valacyclovir was administered to patients based on VZV seropositivity, but RZV was also recommended if patients were on minimal immunosuppression.[54] While the AST also recommended that vaccination with ZVL might be considered for patients aged > 50 who were not severely immunosuppressed,[54] it should be

noted that ZVL is no longer available in the US as of 2020, after the AST guideline was published.[45,48]

In rheumatology, EULAR offered guidance for HZ vaccination in high-risk patients with autoimmune inflammatory rheumatic diseases (AIIRD).[55] As a general principle, vaccines should preferably be administered during disease quiescence and before planned immunosuppression, such as administering ZVL 4 weeks before initiation of biologic or targeted synthetic DMARD (b/tsDMARD).[55] As RZV is a non-live vaccine, it was suggested that RZV vaccination might replace the live-attenuated vaccine in patients with AIIRD.[55] Nevertheless, EULAR deemed there was insufficient evidence for recommending antiviral prophylaxis.[56]

For HIV, RZV was recommended in adults by the US National Institute of Health (NIH).[57] Concurrent antiretroviral therapy (ART) was acceptable, but administration of RZV would be preferred after CD4 count recovery or HIV suppression.[57] The ACIP/CDC recommended RZV in adults aged ≥19 years living with HIV, including those receiving ART and those with advanced disease; further, it was noted that administration of recombinant vaccines does not have to be delayed to meet the criteria of viral suppression or higher CD4 cell counts.[45,48]

Further insights could be observed by comparing National Immunization Programs around the world (Figure 2).[45,48,58–63] As of January 2024, 11 countries have specified RZV vaccination for individuals with IC conditions or at increased risk. Seven of these regions have extended eligibility for RZV reimbursement or subsidy to individuals aged 18 or above.

Overall, each medical discipline or specialty has provided specific recommendations for multiple IC diseases, with low intra-discipline concordance. With currently no formal HZ prophylaxis guidelines in Hong Kong to advise local doctors on the "Who, When, How" of antiviral prophylaxis or vaccination, it thus remains an open issue for everyday practitioners to tailor their recommendations to individual patients, which might lead to inconsistencies when delivering patient care.

Discussion

Consensus among the experts had been reached eventually, materializing as the capstone synthesis of this paper: a local framework for HZ prophylaxis is summarized in Table 2. In the absence of formal guidelines in Hong Kong, this framework intends to provide expert recommendations for local doctors to guide HZ prophylaxis for IC patients. Recommendations from the expert consensus are discussed below by disease area. These findings may be valuable in informing the development of formal HZ prophylaxis guidelines in Hong Kong.

The preferred method of HZ prophylaxis remained antivirals and vaccines. Given the positive clinical outcomes regardless of the causes of IC states, RZV was suggested for HZ prevention in IC patients. Antivirals might be utilized in specific subgroups for prophylaxis, despite being primarily used in HZ treatment.[64] It was expected that antiviral prophylaxis in addition to RZV would have a synergistic effect to minimize the number of breakthrough cases. The defined subgroups at risk of HZ were generally aligned with international guidelines.

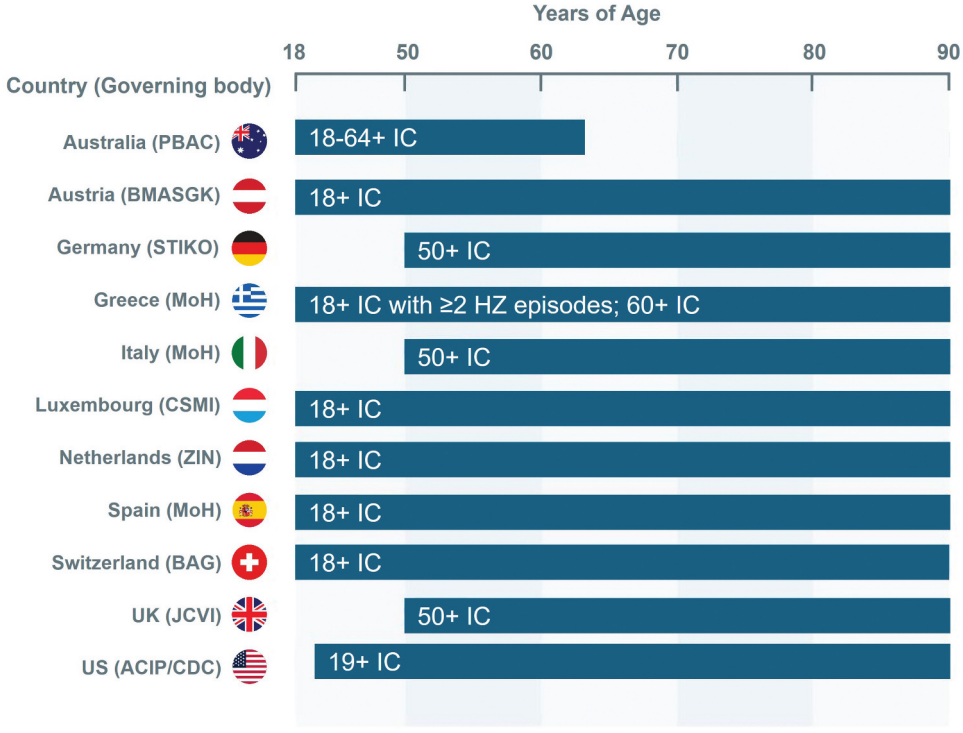

Figure 2. National Immunization Programs covering RZV for IC populations.[45,48,58–63] Abbreviations: ACIP: Advisory Committee on Immunization Practices; BAG: Federal Office of Public Health; BMASGK: Federal Ministry of Social Affairs, Health, Care and Consumer Protection; CDC: Centers for Disease Control and Prevention; CSMI: Higher Council for Infectious Diseases; HZ: Herpes zoster; IC: Immunocompromised; JCVI: Joint Committee on Vaccination and Immunization; MoH: Ministry of Health; PBAC: Pharmaceutical Benefits Advisory Committee; RZV: Recombinant Zoster Vaccine; STIKO: Standing Committee on Vaccination at the Robert Koch Institute; ZIN: National Health Care Institute.

Table 2. Local adaptation of HZ prophylaxis in the IC population.

Category	Population at HZ risk	Recommended timing	Recommended strategy	Guidelines consistent with local recommendation
Hematology	HSCT (autologous & allogenic)	Autologous: at timepoint of ≥3 months post-transplant Allogenic: at timepoint of ≥6 months post-transplant	RZV	ACIP/CDC (2022)[45,48] ASCO (2024)[50]
		Autologous: post-transplant, for duration of ≥ 6–12 months Allogenic: post-transplant, for duration of ≥1 year	Antivirals	NCCN (2023)[49]
	Hematological malignancies[a]	Pre-treatment or when patient is not actively immunosuppressed[b]	RZV	ACIP/CDC (2022)[45,48]
		During treatment including periods of immunosuppression[c]	Antivirals	NCCN (2023)[49]
	Under immunosuppression[d]	When the immune response is likely to be the most robust	RZV	ACIP/CDC (2022)[45,48]
		On B-cell depleting agents: at least 4 weeks prior to the next scheduled therapy		ACIP/CDC (2022)[45,48] ASCO (2024)[50]
Oncology	Cancer patients scheduled for treatment (chemotherapy, immunosuppressants, radiation therapy, splenectomy)	Pre-treatment or in window periods without active antitumor treatment, and when the immune system is not actively immunosuppressed	RZV	ACIP/CDC (2022)[45,48] ASCO (2024)[50]
		During treatment including periods of immunosuppression[c]	Antivirals	NCCN (2023)[49]
	Cancer survivors (disease-free for ≥5 years)	Disease-free patients can be treated according to recommendations for immunocompetent patients	RZV	AIOM (2022)[51]
	Multiple comorbidities, e.g. cardiovascular, pulmonary, renal, liver chronic diseases, diabetes	When the immune system is not actively immunosuppressed	RZV	AIOM (2022)[51,52]
Nephrology	Renal diseases (glomerular disease, nephrotic syndrome, CKD)	Prior to planned immune suppression or when the immune system is not actively immunosuppressed	RZV	KDIGO (2021)[46]
	CKD patients including ESRD and kidney failure	Timing not specified	RZV	New Zealand Ministry of Health (2023)[47]
		Timing not specified, but can be administered in patients on dialysis		NKF[53]
Solid organ transplant	Transplant candidates or recipients (e.g. lung, heart, liver, pancreas, intestine)	Pre-transplant when possible, or 6 months post-transplant	RZV	ACIP/CDC (2022)[45,48]
Rheumatology	Under immunosuppressants (include but not limited to b/tsDMARDs)	Preferably prior to initiation of immunosuppressive medications or at low levels of immunosuppression (in context of disease)	RZV	ACIP/CDC (2022)[45,48]
		Deferral till glucocorticoids tapered to equivalent of prednisone <20 mg/day	RZV	ACR (2023)[65]
		At least 4 weeks prior to the next scheduled anti-B cell therapy	RZV	ACIP/CDC (2022)[45,48]
	Autoimmune inflammatory rheumatic diseases	Optimally administered in the setting of well-controlled diseases	RZV	ACIP/CDC (2022)[45,48] EULAR (2019)[55]
HIV	Including patients under ART and/or with advanced HIV	No delay necessary[e]	RZV	ACIP/CDC (2022)[45,48]

[a]Conditions mentioned in the expert meeting include but are not limited to Hodgkin's disease, lymphoma, ALL, CLL, AML, MDS, MPN, MM.
[b]Referenced guidelines apply to cancer in general and not just hematological malignancies.
[c]In patients receiving proteasome inhibitors.
[d]Immunosuppressants mentioned in the expert meeting include but are not limited to alemtuzumab, daratumumab, elotuzumab, ruxolitinib, BTK/BCL2 inhibitors, proteasome inhibitors.
[e]While greater immunogenicity has been observed in the setting of viral suppression or higher CD4 cell counts, vaccination does not have to be delayed if these criteria have not been met, especially if that would lead to a significant delay in vaccination.

ACIP: Advisory Committee on Immunization Practices; ACR: American College of Rheumatology; AIOM: Associazione Italiana di Oncologia Medica; ALL: Acute lymphocytic leukemia; AML: Acute myeloid leukemia; ART: Antiretroviral therapy; ASCO: American Society of Clinical Oncology; BCL2: B-cell leukemia/lymphoma 2; BTK: Bruton's tyrosine kinase; b/tsDMARD: Biologic and targeted synthetic disease-modifying anti-rheumatic drug; CD4: Cluster of differentiation 4; CDC: Centers for Disease Control and Prevention; CKD: Chronic kidney disease; CLL: Chronic lymphocytic leukemia; ESRD: End stage renal disease; EULAR: European Alliance of Associations for Rheumatology; HIV: Human immunodeficiency virus; HSCT: Hematopoietic stem cell transplant; HZ: Herpes zoster; KDIGO: Kidney Disease: Improving Global Outcomes; MDS: Myelodysplastic syndromes; MM: Multiple myeloma; MPN: Myeloproliferative neoplasms; NCCN: National Comprehensive Cancer Network; NKF: National Kidney Foundation; RZV: Recombinant Zoster Vaccine.

For details on antiviral and vaccine prophylaxis timing, major considerations included the schedule for disease-specific treatment regimen and the level of immunosuppression in IC patients. Local experience led to tailored approaches for specific cases.

For hematological malignancies (except under HSCT), vaccination with RZV should generally be recommended before treatment, in view of the subsequent acute immunosuppression which would diminish vaccination effectiveness, whereas HSCT recipients could benefit from RZV vaccination post-transplant. Similarly, hematology patients with inflammatory conditions requiring immunosuppressants, such as B-cell depleting agents, should also receive HZ prophylaxis with RZV during the window period prior to next scheduled therapy in the regimen.

For oncology, both current cancer patients and survivors were considered. Since treatment for solid tumors might be maintained on a long-term basis, it is inevitable that vaccine prophylaxis, if prescribed, would coincide with cancer treatment. However, vaccine prophylaxis would be desirable during periods when the immune system is not acutely suppressed.

For nephrology, international guidelines did not include specifications for antiviral prophylaxis. One consideration is that CKD and ESRD patients on dialysis are highly susceptible to the side effects of antiviral medications for HZ.[66] As such, the consensus was that CKD patients, including those with ESRD and kidney failure on dialysis, should be vaccinated with RZV provided that the immune system is not acutely suppressed.

For solid organ transplantation, it was suggested that RZV vaccination could be offered at distant timepoints from the index transplant event, when immunosuppressants are prioritized for ameliorating graft-versus-host reaction.

In rheumatology, immunosuppressant use is often administered independently of vaccination. Vaccination with RZV should be considered in patients with AIIRD, preferably during quiescent disease, before administration of immunosuppressants particularly anti-B-cell agents, or after glucocorticoids have been tapered.

Lastly, given the benefit of ART in reducing HZ risk, the ACIP/CDC recommendations for HIV patients were fully adopted.[45,48] Concurrent vaccination with RZV could be provided to HIV patients at any disease stage without delay.[45,48]

Generally, it was observed that the ACIP/CDC guidelines for adult IC patients were commonly adopted for local recommendations, and should also be referenced for IC cases beyond the scope of discussion in this publication.

Challenges in clinical practice

We have summarized our literature review of currently available evidence and national/international recommendations on HZ prophylaxis into more practical, local suggestions. However, in the process of reviewing current HZ prophylaxis strategies, we also identified potential challenges in its implementation.

Uncertainty remains around whether IC patients who have a history of HZ should be vaccinated or re-vaccinated to prevent HZ recurrence. While the ACIP/CDC recommended RZV in IC adults with a history of HZ based on the statement that "HZ can recur," it did not elaborate on the risk-benefit assessment of prophylaxis against recurrence.[45,48] ASCO also supported the use of RZV for preventing future HZ episodes in patients with cancer and previous HZ episodes.[50] Regardless, there still exists a lack of studies to verify the vaccination needs among IC individuals for recurrent HZ.

Another concern remains on the requirement for booster doses in vaccinated IC patients. There are currently no recommendations for RZV booster doses, regardless of IC state. Nevertheless, the long-term protection conferred by RZV has been demonstrated in immunocompetent patients in the ZOE-LTFU study, reporting high VE (89.0%) and CMI responses (median gE-specific CD4[2+] T cell frequency: 684.4) up to 10 years post-vaccination.[67] Yet, it should be noted that the ZOE-LTFU study excluded patients with IC conditions,[68] and the long-term response of RZV in IC patients would therefore require further study to ascertain. On the other hand, the ACIP/CDC and ASCO have encouraged all patients previously vaccinated with ZVL to also receive RZV given rapidly waning ZVL efficacy,[50,69,70] but such an approach might not be practical locally.

More importantly, patient acceptance of vaccination could be influenced by reimbursement due to financial concerns. In a recent survey of 400 local patients from a government outpatient clinic, 29% accepted HZ vaccination citing the reasonable price, but another 21% found it too expensive.[71] An economic analysis has shown that mass vaccination could reduce HZ cases by 23% in Hong Kong, thereby alleviating public health burden.[4] With local preventive measures ready, the next hurdle would be for the wider healthcare community to actualize these updates and make HZ prevention accessible to all.

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Author contributions

All authors contributed to the concept, analysis, and critical revision of the article. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

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Ethical approval is not required as this is not an interventional study.

References

1. Harpaz R, Ortega-Sanchez IR, Seward JF. Prevention of herpes zoster: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep. 2008;57 (RR–5):1–4; quiz CE32-34.
2. Gershon AA, Steinberg SP. Cellular and humoral immune responses to varicella-zoster virus in immunocompromised patients during and after varicella-zoster infections. Infect Immun. 1979;25(1):170–174. doi:10.1128/iai.25.1.170-174.1979.
3. Muñoz-Quiles C, López-Lacort M, Díez-Domingo J, Orrico-Sánchez A. Herpes zoster risk and burden of disease in immunocompromised populations: a population-based study using health system integrated databases, 2009–2014. BMC Infect Dis. 2020;20 (1):905. doi:10.1186/s12879-020-05648-6.
4. Chan PKS, Wong MCS, Chan M, Ching K, Giannelos N, Ng C. Public health impact of herpes zoster vaccination on older adults in Hong Kong. Hum Vaccines & Immunotherapeutics. 2023;19 (1):2176065. doi:10.1080/21645515.2023.2176065.
5. Seroprevalence rates of varicella zoster virus antibodies. Hong Kong Department of Health. 2017. [accessed 2023 Dec 20]. https://www.chp.gov.hk/en/statistics/data/10/641/701/3691.html.
6. Wong TYA. 10 FAQs about prevention of herpes zoster for healthcare professionals. J Soc Physicians Hong Kong. 2021;13 (9):123–128.
7. Yu W, Chan P, You J. Clinical and economic outcomes of patients hospitalized for herpes zoster in Hong Kong. Value Health. 2016;19(7):A413. doi:10.1016/j.jval.2016.09.384.
8. AHRQ QI. ICD-10-CM/PCS specification v2023, prevention quality indicators appendices: Appendix C: Immunocompromised state diagnosis and procedure code. U.S. Department of Health & Human Services. [accessed 2024 Apr 19]. https://qualityindicators.ahrq.gov/Downloads/Modules/PQI/V2023/TechSpecs/PQI_Appendix_C.pdf.
9. Qian J, Heywood AE, Karki S, Banks E, Macartney K, Chantrill L, Liu B. Risk of herpes zoster prior to and following cancer diagnosis and treatment: A population-based prospective cohort study. J Infect Dis. 2019;220(1):3–11. doi:10.1093/infdis/jiy625.
10. Forbes HJ, Bhaskaran K, Thomas SL, Smeeth L, Clayton T, Langan SM. Quantification of risk factors for herpes zoster: Population based case-control study. BMJ. 2014;348:g2911. doi:10.1136/bmj.g2911.
11. Lin SY, Liu J-H, Lin C-L, Tsai I-J, Chen P-C, Chung C-J, Liu Y-L, Wang I-K, Lin H-H, Huang C-C. A comparison of herpes zoster incidence across the spectrum of chronic kidney disease, dialysis and transplantation. Am J Nephrol. 2012;36(1):27–33. doi:10.1159/000339004.
12. Pergam SA, Forsberg CW, Boeckh MJ, Maynard C, Limaye AP, Wald A, Smith NL, Young BA. Herpes zoster incidence in a multicenter cohort of solid organ transplant recipients. Transpl Infect Dis. 2011;13(1):15–23. doi:10.1111/j.1399-3062.2010.00547.x.
13. Yun H, Yang S, Chen L, Xie F, Winthrop K, Baddley JW, Saag KG, Singh J, Curtis JR. Risk of Herpes zoster in autoimmune and inflammatory diseases: Implications for Vaccination. Arthritis Rheumatol. 2016;68(9):2328–2337. doi:10.1002/art.39670.
14. Marra F, Lo E, Kalashnikov V, Richardson K. Risk of herpes zoster in individuals on biologics, disease-modifying antirheumatic drugs, and/or corticosteroids for autoimmune diseases: A systematic review and meta-analysis. Open Forum Infect Dis. 2016;3(4):ofw205. doi:10.1093/ofid/ofw205.
15. Marra F, Parhar K, Huang B, Vadlamudi N. Risk factors for herpes zoster infection: A meta-analysis. Open Forum Infect Dis. 2020;7 (1):ofaa005. doi:10.1093/ofid/ofaa005.
16. Ku HC, Tsai Y-T, Konara-Mudiyanselage S-P, Wu Y-L, Yu T, Ko N-Y. Incidence of herpes zoster in HIV-infected patients undergoing antiretroviral therapy: A systematic review and meta-analysis. J Clin Med. 2021;10(11):2300. doi:10.3390/jcm10112300.
17. Li Z, Wang Q, Ma J, Li Z, Huang D, Huang Y, Zhou H. Risk factors for herpes zoster in patients with chronic kidney disease: A case-control study. Vaccines (Basel). 2021;9(9):963. doi:10.3390/vaccines9090963.
18. Mok CC, So H, Yim CW, To CH, Lao WN, Wong SPY, Ng HY, Lee JMY, Lee PML, Ying SKY, et al. Safety of the JAK and TNF inhibitors in rheumatoid arthritis: Real world data from the Hong Kong biologics registry. Rheumatology (Oxford). 2024;63 (2):358–365. doi:10.1093/rheumatology/kead198.
19. Ming WK, Yu W, Tsang O, Chan P, You J. Economic analysis of herpes zoster in a hospital setting in Hong Kong. Acta Derm Venereol. 2019;99(6):616–617. doi:10.2340/00015555-3118.
20. Yanni EA, Ferreira G, Guennec M, El Hahi Y, El Ghachi A, Haguinet F, Espie E, Bianco V. Burden of herpes zoster in 16 selected immunocompromised populations in England: A cohort study in the clinical practice research datalink 2000–2012. BMJ Open. 2018;8(6):e020528. doi:10.1136/bmjopen-2017-020528.
21. Shingrix® (Herpes Zoster vaccine (recombinant, adjuvanted)) [Prescribing Information]. GSK group of companies. 2021, version GDS06.
22. LCQ11: Herpes Zoster. The Government of the Hong Kong Special Administrative Region press releases. 2022. [Accessed 2024 Nov 12]. https://www.info.gov.hk/gia/general/202205/04/P2022050400558.htm.
23. Building a Shingles Atlas for Adult Vaccination Hong Kong. Vaccines 4 Life. 2021. [Accessed 2024 Nov 12]. https://www.vaccines4life.com/wp-content/uploads/2021/05/SAAV_Environmental-Scan_Hong-Kong.pdf.
24. McKay SL, Guo A, Pergam SA, Dooling K. Herpes Zoster risk in immunocompromised adults in the United States: A systematic review. Clin Infect Dis. 2020;71(7):e125–e134. doi:10.1093/cid/ciz1090.
25. Kausar S, Said Khan F, Ishaq Mujeeb Ur Rehman M, Akram M, Riaz M, Rasool G, Hamid Khan A, Saleem I, Shamim S, Malik A. A review: Mechanism of action of antiviral drugs. Int J Immunopathol Pharmacol. 2021;35:20587384211002621. doi:10.1177/20587384211002621.

26. Heineman TC, Cunningham A, Levin M. Understanding the immunology of Shingrix, a recombinant glycoprotein E adjuvanted herpes zoster vaccine. Curr Opin Immunol. 2019;59:42–48. doi:10.1016/j.coi.2019.02.009.
27. Zheng G, Guan F, Han X, Yang L, Zhao Y, Yang Y, Zhang E, He J, He D, Wu W, et al. Efficacy of intermittent, oral famciclovir prophylaxis for bortezomib-induced herpes zoster in multiple myeloma patients. Front Oncol. 2022;12:843032. doi:10.3389/fonc.2022.843032.
28. Xia Y, Zhang X, Zhang L, Fu C. Efficacy, effectiveness, and safety of herpes zoster vaccine in the immunocompetent and immunocompromised subjects: A systematic review and network meta-analysis. Front Immunol. 2022;13:978203. doi:10.3389/fimmu.2022.978203.
29. Erard V, Guthrie KA, Varley C, Heugel J, Wald A, Flowers MED, Corey L, Boeckh M. One-year acyclovir prophylaxis for preventing varicella-zoster virus disease after hematopoietic cell transplantation: No evidence of rebound varicella-zoster virus disease after drug discontinuation. Blood. 2007;110(8):3071–3077. doi:10.1182/blood-2007-03-077644.
30. Ilyas S, Chandrasekar PH. Preventing varicella-zoster: Advances with the recombinant zoster vaccine. Open Forum Infect Dis. 2020;7(7):ofaa274. doi:10.1093/ofid/ofaa274.
31. Girmenia C, Ciceri F, Corradini P, Cuneo A, D'Ancona F, Musto P, Risitano AM, Voso MT, Venditti A, Barosi G. Towards a personalized preventive strategy of herpes zoster infection in patients with hematologic diseases or hematopoietic stem cell transplant recipients: A position paper from an ad hoc Italian expert panel. Haematologica. 2023;109(11):3496–3504. doi:10.3324/haematol.2023.284417.
32. Overview of herpes zoster vaccines. SPH Pharmacy Department. 2021. [Accessed 2023 Dec 20]. https://www.stpaul.org.hk/storage/media/Doctor%20Zone/Newsletter/Newsletter_Issue_109.pdf.
33. Zostavax® (Live attenuated varicella-zoster virus (Oka/Merck strain) [Prescribing Information]. [Accessed 2024 Feb 21]. https://www.mims.com/hongkong/drug/info/zostavax?type=full.
34. Goud R, Lufkin B, Duffy J, Whitaker B, Wong H-L, Liao J, Lo A-C, Parulekar S, Agger P, Anderson SA, et al. Risk of Guillain-Barré syndrome following recombinant zoster vaccine in Medicare beneficiaries. JAMA Intern Med. 2021;181(12):1623–1630. doi:10.1001/jamainternmed.2021.6227.
35. Nelson JC, Ulloa-Pérez E, Yu O, Cook AJ, Jackson ML, Belongia EA, Daley MF, Harpaz R, Kharbanda EO, Klein NP, et al. Active postlicensure safety surveillance for recombinant zoster vaccine using electronic health record data. Am J Epidemiol. 2023;192(2):205–216. doi:10.1093/aje/kwac170.
36. Janusz CB, Anderson TC, Leidner AJ, Lee GM, Dooling K, Prosser LA. Projected risks and health benefits of vaccination against herpes zoster and related complications in US adults. Hum Vaccines & Immunotherapeutics. 2022;18(5):2060668. doi:10.1080/21645515.2022.2060668.
37. Bastidas A, de la Serna J, El Idrissi M, Oostvogels L, Quittet P, López-Jiménez J, Vural F, Pohlreich D, Zuckerman T, Issa NC, et al. Effect of recombinant zoster vaccine on incidence of herpes zoster after autologous stem cell transplantation: A randomized clinical trial. JAMA. 2019;322(2):123–133. doi:10.1001/jama.2019.9053.
38. Dagnew AF, Rausch D, Hervé C, Zahaf T, Levin MJ, Schuind A. Efficacy and serious adverse events profile of the adjuvanted recombinant zoster vaccine in adults with pre-existing potential immune-mediated diseases: A pooled post hoc analysis on two parallel randomized trials. Rheumatology (Oxford). 2021;60(3):1226–1233. doi:10.1093/rheumatology/keaa424.
39. Dagnew AF, Ilhan O, Lee W-S, Woszczyk D, Kwak J-Y, Bowcock S, Sohn SK, Rodriguez Macías G, Chiou T-J, Quiel D, et al. Immunogenicity and safety of the adjuvanted recombinant zoster vaccine in adults with haematological malignancies: A phase 3, randomised, clinical trial and post-hoc efficacy analysis. Lancet Infect Dis. 2019;19(9):988–1000. doi:10.1016/S1473-3099(19)30163-X.
40. Vink P, Delgado Mingorance I, Maximiano Alonso C, Rubio-Viqueira B, Jung KH, Rodriguez Moreno JF, Grande E, Marrupe Gonzalez D, Lowndes S, Puente J, et al. Immunogenicity and safety of the adjuvanted recombinant zoster vaccine in patients with solid tumors, vaccinated before or during chemotherapy: A randomized trial. Cancer. 2019;125(8):1301–1312. doi:10.1002/cncr.31909.
41. Vink P, Ramon Torrell JM, Sanchez Fructuoso A, Kim S-J, Kim S-I, Zaltzman J, Ortiz F, Campistol Plana JM, Fernandez Rodriguez AM, Rebollo Rodrigo H, et al. Immunogenicity and safety of the adjuvanted recombinant zoster vaccine in chronically immunosuppressed adults following renal transplant: A phase 3, randomized clinical trial. Clin Infect Dis. 2020;70(2):181–190. doi:10.1093/cid/ciz177.
42. Berkowitz EM, Moyle G, Stellbrink H-J, Schürmann D, Kegg S, Stoll M, El Idrissi M, Oostvogels L, Heineman TC, Brockmeyer N, et al. Safety and immunogenicity of an adjuvanted herpes zoster subunit candidate vaccine in hiv-infected adults: A phase 1/2a randomized, placebo-controlled study. J Infect Dis. 2015;211(8):1279–1287. doi:10.1093/infdis/jiu606.
43. Källmark HGB, Nagel J, Einarsson J, Jönsson G, Kahn F, Kahn R, Bangtsson A, Bergström T, Kapetanovic M. Immunogenicity of adjuvanted herpes zoster subunit vaccine in rheumatoid arthritis patients treated with Janus kinase inhibitors and controls: Preliminary results. Arthritis Rheumatol. 2020;72(Suppl 10):4003. doi:10.1002/art.41538.
44. Venerito V, Stefanizzi P, Cantarini L, Lavista M, Galeone MG, Di Lorenzo A, Iannone F, Tafuri S, Lopalco G. Immunogenicity and safety of adjuvanted recombinant zoster vaccine in rheumatoid arthritis patients on anti-cellular biologic agents or JAK inhibitors: A prospective observational study. Int J Mol Sci. 2023;24(8):6967. doi:10.3390/ijms24086967.
45. Clinical Considerations for Shingrix Use in Immunocompromised Adults Aged ≥19 Years. Centers for Disease Control and Prevention. Updated 2024 Jul 9. 2022 [Accessed 2023 Dec 18]. https://www.cdc.gov/shingles/hcp/vaccine-considerations/immunocompromised-adults.html.
46. Rovin BH, Adler SG, Barratt J, Bridoux F, Burdge KA, Chan TM, Cook HT, Fervenza FC, Gibson KL, Glassock RJ, et al. KDIGO 2021 clinical practice guideline for the management of glomerular diseases. Kidney Int. 2021;100(4):S1–S276. doi:10.1016/j.kint.2021.05.021.
47. Immunisation Handbook. Zoster (herpes zoster/shingles). Ministry of Health - Manatu Hauora. 2020. [Accessed 2023 Dec 18]. https://www.health.govt.nz/our-work/immunisation-handbook-2020/23-zoster-herpes-zoster-shingles#22-5.
48. Anderson TC, Masters NB, Guo A, Shepersky L, Leidner AJ, Lee GM, Kotton CN, Dooling KL. Use of recombinant zoster vaccine in immunocompromised adults aged ≥19 years: Recommendations of the advisory committee on immunization practices — United States, 2022. MMWR Morb Mortal Wkly Rep. 2022;71(3):80–84. doi:10.15585/mmwr.mm7103a2.
49. Prevention and treatment of cancer-related infections: Version 1.2023. National Comprehensive Cancer Network. 2023 [Accessed 2023 Dec 18]. https://www.nccn.org/professionals/physician_gls/pdf/infections.pdf.
50. Kamboj M, Bohlke K, Baptiste DM, Dunleavy K, Fueger A, Jones L, Kelkar AH, Law LY, LeFebvre KB, Ljungman P, et al. Vaccination of adults with cancer: ASCO guideline. J Clin Oncol. 2024;42(14):1699–1721. doi:10.1200/JCO.24.00032.
51. Pedrazzoli P, Lasagna A, Cassaniti I, Ferrari A, Bergami F, Silvestris N, Sapuppo E, Di Maio M, Cinieri S, Baldanti F. Vaccination for herpes zoster in patients with solid tumors: A position paper on the behalf of the Associazione Italiana di Oncologia Medica (AIOM). ESMO Open. 2022;7(4):100548. doi:10.1016/j.esmoop.2022.100548.
52. Andreoni M, Sticchi L, Nozza S, Sarmati L, Gori A, Tavio M. Recommendations of the Italian society for infectious and tropical diseases (SIMIT) for adult vaccinations. Hum Vaccin Immunother. 2021;17(11):4265–4282. doi:10.1080/21645515.2021.1971473.

53. Vaccines for adults with advanced chronic kidney disease, kidney failure, or kidney transplant. National Kidney Foundation. 2023 [Accessed 2023 Dec 18]. https://www.kidney.org/atoz/content/vaccinations.
54. Pergam SA, Limaye AP. Varicella zoster virus in solid organ transplantation: Guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. Clin Transpl. 2019;33(9):e13622. doi:10.1111/ctr.13622.
55. Furer V, Rondaan C, Heijstek MW, Agmon-Levin N, van Assen S, Bijl M, Breedveld FC, D'Amelio R, Dougados M, Kapetanovic MC, et al. 2019 update of EULAR recommendations for vaccination in adult patients with autoimmune inflammatory rheumatic diseases. Ann Rheum Dis. 2020;79(1):39–52. doi:10.1136/annrheumdis-2019-215882.
56. Fragoulis GE, Nikiphorou E, Dey M, Zhao SS, Courvoisier DS, Arnaud L, Atzeni F, Behrens GM, Bijlsma JW, Böhm P, et al. 2022 EULAR recommendations for screening and prophylaxis of chronic and opportunistic infections in adults with autoimmune inflammatory rheumatic diseases. Ann Rheum Dis. 2023;82(6):742–753. doi:10.1136/ard-2022-223335.
57. Guidelines for the prevention and treatment of opportunistic infections in adults and adolescents with HIV: Varicella-zoster virus diseases. NIH Office of AIDS Research. 2023. [Accessed 2023 Dec 20]. https://clinicalinfo.hiv.gov/en/guidelines/hiv-clinical-guidelines-adult-and-adolescent-opportunistic-infections/varicella-zoster?view=full.
58. Pharmaceutical Benefits Advisory Committee (PBAC) meeting outcomes: November 2023 PBAC meeting. Australian Department of Health and Aged Care. 2023. [Accessed 2023 Dec 21]. https://www.pbs.gov.au/industry/listing/elements/pbac-meetings/pbac-outcomes/2023-03/pbac-web-outcomes-03-2023-v3.pdf.
59. Parikh R, Widenmaier R, Lecrenier N. A practitioner's guide to the recombinant zoster vaccine: Review of national vaccination recommendations. Expert Rev Vaccines. 2021;20(9):1065–1075. doi:10.1080/14760584.2021.1956906.
60. National adult immunization program 2023. Greece Ministry of Health. 2023. [Accessed 2023 Dec 21]. https://www.moh.gov.gr/articles/health/dieythynsh-dhmosias-ygieinhs/emboliasmoi/ethniko-programma-emboliasmwn-epe-enhlikwn/11251-ethniko-programma-emboliasmwn-enhlikwn-2023?fdl=24972.
61. Free shingles vacscine for people aged 65 and over and immunocompromised people. The Luxembourg Government Ministry of Health. 2023. [Accessed 2023 Dec 21]. https://msss.gouvernement.lu/en/actualites.gouvernement+en+actualites+toutes_actualites+communiques+2023+04-avril+12-vaccin-gratuit-zona.html.
62. GVS advice RZV (Shingrix®). For the prevention of herpes zoster and related post-herpetic neuralgia. National Health Care Institute. 2021. [Accessed 2023 Dec 21]. https://english.zorginstituutnederland.nl/publications/reports/2021/06/14/gvs-advice-shingrix.
63. Evaluation of vaccines and vaccination against herpes zoster (Zostavax® and Shingrix®). Switzerland Federal Office of Public Health. 2021. [Accessed 2023 Dec 21]. https://www.bag.admin.ch/bag/en/home/krankheiten/krankheiten-im-ueberblick/windpocken.html#:~:text=EMP_211117_EKIF%20FOPH_Analytic%20Frame%20SHINGRIX_final%20(PDF%2C%201%20MB%2C%2018.11.2021).
64. Kwok SK. Herpes zoster ophthalmicus – a family physician's perspective. HK Pract. 2001;23:57–62.
65. Bass AR, Chakravarty E, Akl EA, Bingham CO, Calabrese L, Cappelli LC, Johnson SR, Imundo LF, Winthrop KL, Arasaratnam RJ, et al. 2022 American College of Rheumatology guideline for vaccinations in patients with rheumatic and musculoskeletal diseases. Arthritis Care Res (Hoboken). 2023;75(3):449–464. doi:10.1002/acr.25045.
66. Sadjadi SA, Regmi S, Chau T. Acyclovir neurotoxicity in a peritoneal dialysis patient: Report of a case and review of the pharmacokinetics of acyclovir. Am J Case Rep. 2018;19:1459–1462. doi:10.12659/AJCR.911520.
67. Strezova A, Diez-Domingo J, Al Shawafi K, Tinoco JC, Shi M, Pirrotta P, Mwakingwe-Omari A, Adams M, Ahonen A, Andrews C, et al. Long-term protection against herpes zoster by the adjuvanted recombinant zoster vaccine: Interim efficacy, immunogenicity, and safety results up to 10 years after initial vaccination. Open Forum Infect Dis. 2022;9(10):ofac485. doi:10.1093/ofid/ofac485.
68. A long-term follow-up Study (ZOE-LTFU) of two studies 110390 (ZOSTER-006) and 113077 (ZOSTER-022) to assess the efficacy, safety, and immunogenicity persistence of GSK biologicals' herpes zoster subunit (Hz/su) vaccine and assessment of 1 or 2 additional doses in two subgroups of older adults. ClinicalTrials.gov. 2024. [Accessed 2024 Nov 12]. https://clinicaltrials.gov/study/NCT02723773?term=NCT02723773&rank=1.
69. Shingrix recommendations. Centers for Disease Control and Prevention. Updated 2024 Oct 22. 2022 [Accessed 2023 Dec 19]. https://www.cdc.gov/shingles/hcp/vaccine-considerations/index.html.
70. Dooling KL, Guo A, Patel M, Lee GM, Moore K, Belongia EA, Harpaz R. Recommendations of the Advisory Committee on Immunization Practices for use of herpes zoster vaccines. MMWR Morb Mortal Wkly Rep. 2018;67(3):103–108. doi:10.15585/mmwr.mm6703a5.
71. Cheng LY. A pilot study to assess the awareness of herpes zoster and the attitudes towards herpes zoster vaccination among Chinese patients attending a government general out-patient clinic in Hong Kong. HK Pract. 2019;41:60–65.