



REVIEW ARTICLE

POPULATION AGING AND THE RISE OF REFRACTORY LEUKEMIAS: SURVEILLANCE, SCREENING AND STRATEGIC HEALTH PLANNING

Aakib Rahman Parray 

Department of Psychology, Akal University, India.

Article Info:



Article History:

Received: 9 August 2025

Reviewed: 14 September 2025

Accepted: 23 October 2025

Published: 15 November 2025

Cite this article:

Parray AR. Population aging and the rise of refractory leukemias: surveillance, screening and strategic health planning. Universal Journal of Pharmaceutical Research 2025; 10(5): 94-98.
<http://doi.org/10.22270/ujpr.v10i5.1430>

*Address for Correspondence:

Aakib Rahman Parray, Department of Biomedical and Laboratory Science, Africa University, Zimbabwe.
E-mail: parray_ar@yahoo.com

Abstract

The global demographic shift towards an aging population has led to a marked increase in the incidence of refractory leukemias, posing significant challenges for healthcare systems worldwide. Older adults are disproportionately affected by leukemias that are resistant to conventional therapies, resulting in poorer prognoses and increased morbidity. This review explores the multifaceted impact of population aging on the epidemiology and management of refractory leukemias, highlighting the urgent need for tailored public health interventions. Effective surveillance systems are critical to monitoring trends in leukemia incidence, treatment resistance, and outcomes among elderly populations. Enhanced data collection and integration of molecular and clinical markers can improve early identification of high-risk individuals and inform resource allocation. Additionally, risk-based screening strategies adapted to the unique needs of older adults have the potential to facilitate earlier diagnosis and improve responsiveness to treatment, ultimately reducing the progression to refractory disease. Strategic health planning that incorporates multidisciplinary care models, public health policy initiatives, and community engagement is essential to address the complex care needs of elderly leukemia patients. Investments in healthcare infrastructure, provider training, and supportive services will improve quality of life and clinical outcomes. Collaborative efforts to integrate surveillance and screening into comprehensive health plans can help mitigate the growing public health burden of refractory leukemias in aging populations.

Keywords: Health planning, population aging, refractory leukemias, surveillance, screening.

INTRODUCTION

The global population is undergoing a profound demographic transition characterized by a rapid increase in the proportion of older adults. According to the World Health Organization, the number of people aged 60 years and older is expected to double by 2050, reaching nearly 2.1 billion worldwide^{1,2}. This aging trend has far-reaching implications for public health, particularly with respect to the rising prevalence of chronic diseases, including hematologic malignancies such as leukemias^{3,4,5}. Among these, refractory leukemias that fail to respond or relapse after standard treatment are emerging as a significant concern due to their increasing incidence in the elderly^{6,7}. Leukemias represent a heterogeneous group of blood cancers⁸, with chronic myeloid leukemia (CML) and chronic lymphocytic leukemia (CLL) being among the most common types diagnosed in older adults^{9,10}. The biology of leukemia in this population is distinct, often involving complex genetic alterations and age-related

changes in immune function that contribute to disease progression and treatment resistance¹⁰. These refractory forms of leukemia are associated with poor prognosis and limited therapeutic options, presenting challenges not only for individual patient care but also for healthcare systems tasked with managing growing caseloads¹¹.

Age-related immune senescence, characterized by a decline in the function of the immune system, plays a pivotal role in the pathogenesis of refractory leukemias. The diminished capacity of immune surveillance in elderly individuals allows for the persistence and proliferation of malignant clones resistant to therapy^{12,13}. Additionally, comorbid conditions common in older adults complicate treatment decisions and increase vulnerability to adverse drug effects, further complicating leukemia management^{14,15}. Surveillance systems are crucial for tracking epidemiological trends and treatment outcomes of refractory leukemias in aging populations^{16,17}. However, current surveillance efforts often lack the

granularity needed to capture age-specific nuances in disease biology and therapy response. There is a pressing need to enhance cancer registries and hematologic databases to include molecular and clinical markers pertinent to refractory disease^{18,19}, which would enable more precise monitoring and timely interventions.

Early detection through screening remains a cornerstone in improving outcomes for many cancers, but standardized leukemia screening protocols for elderly populations are limited^{20,21,22}. Developing risk-based screening strategies tailored to the elderly could facilitate the identification of pre-leukemic conditions and early-stage disease, allowing for interventions before progression to refractory leukemia²³. Nevertheless, implementing such screening programs presents challenges, including balancing the benefits and risks in a population often burdened by frailty and comorbidities²⁴. Strategic health planning is imperative to address the complexities of refractory leukemia care in the elderly. This involves fostering multidisciplinary care models that integrate hematology, geriatrics, pharmacy, and psychosocial support, ensuring that treatment plans are individualized and holistic^{25,26}. Public health policies must also focus on improving access to novel therapies, supportive care, and patient education to enhance quality of life and clinical outcomes for this vulnerable group^{27,28}. This review aims to explore the intersection of population aging with the rise of refractory leukemias, emphasizing the roles of enhanced surveillance, tailored screening, and strategic health planning.

This review aims to critically examine the impact of population aging on the increasing incidence of refractory leukemias, with a focus on the challenges and opportunities in surveillance, screening, and strategic health planning.

Surveillance of refractory leukemias in aging populations

Surveillance plays a fundamental role in understanding and managing the rising burden of refractory leukemias among aging populations^{6,29}. Robust cancer registries and hematologic disease databases serve as essential tools for collecting epidemiological data on leukemia incidence, treatment patterns, and patient outcomes, including rates of treatment resistance and relapse³⁰⁻³². Such data are invaluable for identifying trends, risk factors, and geographic or demographic disparities in refractory leukemia occurrence among older adults³²⁻³⁴. However, existing surveillance systems often fall short in capturing the complexity of refractory leukemias in the elderly. Many registries lack detailed molecular and genetic information that characterizes refractory disease, as well as comprehensive clinical data on patient comorbidities, functional status, and geriatric assessments³⁵. This gap limits the ability to stratify risk accurately and tailor interventions for the elderly, who may experience different disease biology and treatment tolerability compared to younger patients³⁶.

To address these challenges, integrating advanced diagnostic biomarkers, including genetic mutations and immune profiling, into surveillance frameworks is crucial. Electronic health records linked with cancer

registries can facilitate real-time data capture and enhance monitoring of treatment responses^{37,38}. Additionally, surveillance efforts should incorporate patient-reported outcomes and quality-of-life measures, which are particularly relevant in elderly populations where treatment goals often balance disease control with maintaining functional independence^{39,40}. Enhanced surveillance systems enable health authorities to detect emerging patterns of resistance early and allocate resources more efficiently⁴¹. They also provide the foundation for evaluating the effectiveness of public health interventions and informing clinical guidelines tailored to the aging demographic.

Screening approaches for early detection

Early detection of leukemia is critical to improving prognosis⁴², especially among older adults who are at increased risk of developing refractory forms of the disease⁷. Despite the success of screening programs for many solid tumors, standardized screening protocols for leukemias remain limited, largely due to the disease's heterogeneity and often asymptomatic early stages⁴³. Nonetheless, targeted screening in high-risk elderly populations has the potential to facilitate timely diagnosis and intervention, thereby reducing progression to refractory leukemia⁴⁴. Risk-based screening strategies tailored to the aging population should incorporate a combination of clinical, genetic, and environmental factors⁴⁵. Routine blood tests such as complete blood counts (CBC) conducted during regular health assessments can serve as an initial screening tool to detect hematologic abnormalities indicative of early leukemia or pre-leukemic states such as myelodysplastic syndromes^{46,47}. Advances in molecular diagnostics have also enabled the identification of genetic mutations and chromosomal abnormalities that predispose individuals to treatment-resistant leukemia, providing opportunities for earlier detection⁴⁸.

Implementing screening programs in elderly populations requires careful consideration of the balance between benefits and potential harms. Frailty, comorbidities, and limited life expectancy may influence the appropriateness and frequency of screening interventions^{14,49}. Additionally, invasive diagnostic procedures following abnormal screening results must be judiciously applied to minimize patient burden⁵⁰. Health education campaigns aimed at increasing awareness among healthcare providers and older adults about leukemia risk factors and the importance of early hematologic evaluation are crucial to improving screening uptake and effectiveness^{51,52}.

Strategic health planning for managing refractory leukemias

Strategic health planning is essential to effectively manage the increasing burden of refractory leukemias in aging populations^{6,21,53}. Given the complexity of these diseases and the unique challenges faced by elderly patients, health systems must adopt comprehensive, coordinated approaches that integrate prevention, early detection, treatment, and supportive care⁵⁴. Central to this strategy is the development of multidisciplinary care models that bring together

hematologists, geriatricians, oncologists, pharmacists, social workers, and palliative care specialists to address the multifaceted needs of older leukemia patients^{26,27}. Investing in healthcare infrastructure and workforce training is critical for optimizing leukemia management. Healthcare providers need specialized knowledge about the interplay between aging biology, comorbidities, and treatment resistance to tailor therapies that maximize efficacy while minimizing adverse effects⁵⁵⁻⁵⁷. Additionally, expanding access to novel targeted therapies and immunotherapies many of which have shown promise in overcoming resistance mechanisms can improve outcomes for elderly patients who often have limited tolerance for intensive chemotherapy^{56,58}.

Public health policies must prioritize equitable access to diagnostic services and comprehensive care across diverse settings, including rural and underserved communities where healthcare resources may be scarce⁵⁹. Health planners should also emphasize patient-centered care by incorporating quality-of-life considerations, psychosocial support, and caregiver involvement into treatment plans^{60,61}. Community engagement and patient education initiatives can empower older adults and their families to participate actively in decision-making and self-management, which is especially important in chronic, refractory disease scenarios. Furthermore, surveillance data should inform strategic planning by identifying high-risk groups, monitoring treatment outcomes, and evaluating intervention effectiveness⁶². Integrating these data into national cancer control programs can guide resource allocation and policy development. Ultimately, a forward-looking, evidence-based strategic plan that adapts to demographic changes and advances in leukemia research will be vital to mitigating the public health impact of refractory leukemias in aging populations⁶³.

Recommendations

1. **Enhance surveillance systems:** Strengthen cancer registries and hematologic databases to include comprehensive molecular, genetic, and clinical data specific to refractory leukemias in older adults. Incorporate patient-reported outcomes and quality-of-life metrics to capture the full impact of the disease.
2. **Develop risk-based screening protocols:** Design and implement screening strategies tailored to elderly populations that combine routine blood tests with advanced molecular diagnostics. These protocols should balance the benefits of early detection with the risks related to frailty and comorbidities.
3. **Promote multidisciplinary care models:** Foster collaboration among hematologists, geriatricians, oncologists, pharmacists, and supportive care teams to deliver individualized treatment plans that consider aging-related factors and patient preferences.
4. **Expand access to novel therapies:** Facilitate equitable availability of targeted therapies and immunotherapies that show promise in overcoming treatment resistance, especially for

older patients who may not tolerate conventional chemotherapy.

5. **Strengthen healthcare infrastructure and training:** Invest in healthcare workforce development to build expertise in managing refractory leukemias in the elderly, including training in geriatric oncology and palliative care.
6. **Implement public health policies supporting equity:** Ensure that rural and underserved populations have access to leukemia screening, diagnosis, and comprehensive care services through policy reforms and resource allocation.
7. **Enhance patient and caregiver education:** Develop educational programs to raise awareness about leukemia risk factors, symptoms, and the importance of early detection, empowering elderly patients and their caregivers to actively participate in healthcare decisions.
8. **Integrate surveillance data into strategic planning:** Use epidemiological and clinical data from surveillance systems to inform national cancer control programs, guide resource allocation, and evaluate the effectiveness of interventions over time.

CONCLUSIONS

The demographic transition to an older global population has led to a notable rise in refractory leukemias, creating intricate challenges for healthcare systems and public health structures. Older individuals frequently face unique disease biology, greater resistance to treatment, and a heightened load of comorbidities, making diagnosis and management more challenging. To tackle these challenges, advanced surveillance systems are needed that integrate comprehensive molecular and clinical information, along with customized screening approaches aimed at early leukemia detection in this at-risk group.

Strategic health planning should focus on multidisciplinary, patient-focused care models that combine innovative treatments, geriatric knowledge, and supportive services to enhance outcomes for elderly patients with refractory leukemias. Furthermore, community involvement and education are essential for enhancing awareness and involvement in early detection and treatment programs.

ACKNOWLEDGEMENTS

The authors would like to thank Africa University, Zimbabwe to provide necessary facilities for this work.

AUTHOR'S CONTRIBUTION

Parray AR: conceived the idea, writing the manuscript, literature survey, formal analysis, critical review.

DATA AVAILABILITY

Data will be made available on request.

CONFLICT OF INTEREST

None to declare.

REFERENCES

- Naja S, Makhlof MM, Chehab MA. An ageing world of the 21st century: A literature review. *Int J Comm Med Public Health* 2017;4(12):4363-9. <https://doi.org/10.18203/2394-6040.ijcmph20175306>
- Jakovljevic M, Westerman R, Sharma T, et al. In Handbook of global health. Cham: Springer Intern Pub 2021:73-102. https://doi.org/10.1007/978-3-030-45009-0_4
- Franceschi C, Garagnani P, Morsiani C, et al. The continuum of aging and age-related diseases: common mechanisms but different rates. *Front Med* 2018;5:61. <https://doi.org/10.3389/fmed.2018.00061>
- Reece AS, Hulse GK. Clinical epigenomic explanation of the epidemiology of cannabinoid genotoxicity manifesting as transgenerational teratogenesis, cancerogenesis and aging acceleration. *Int J Env Res Pub Health* 2023;20(4):3360. <https://doi.org/10.3390/ijerph20043360>
- Braithwaite D, Anton S, Mohile S, et al. Cancer and aging: A call to action. *AgiCanc* 2022;3(2):87-94. <https://doi.org/10.1002/aac2.12055>
- Bryan JC, Jabbour EJ. Management of relapsed/refractory acute myeloid leukemia in the elderly: Current strategies and developments. *Drug Agi* 2015;32(8):623-37. <https://doi.org/10.1007/s40266-015-0285-6>
- Ferrara F, Lessi F, Vitagliano O, et al. Current therapeutic results and treatment options for older patients with relapsed acute myeloid leukemia. *Canc* 2019;11(2):224. <https://doi.org/10.3390/cancers11020224>
- Jurlander J. Hematological malignancies, leukemias and lymphomas. *Encyc Canc* 2011:1640-1644. https://doi.org/10.1007/978-3-642-16483-5_2615
- Rodriguez-Vicente AE, Díaz MG, Hernández-Rivas JM. Chronic lymphocytic leukemia: A clinical and molecular heterogeneous disease. *Canc Gene* 2013;206(3):49-62. <https://doi.org/10.1016/j.cancergen.2013.01.003>
- Isidori A, Loscocco F, Ciciarello M, et al. Immunosenescence and immunotherapy in elderly acute myeloid leukemia patients: Time for a biology-driven approach. *Canc* 2018;10(7):211. <https://doi.org/10.3390/cancers10070211>
- Kurtin S. Interdisciplinary management of acute leukemia across the continuum of care. *Semi Onco Nurs* 2019;35(6):150953. <https://doi.org/10.1016/j.soncn.2019.150953>
- Derhovanessian E, Solana R, Larbi A, Immunity, ageing and cancer. *Immu Age* 2008;5(1):11. <https://doi.org/10.1186/1742-4933-5-11>
- Bird J, Cavenagh J, Hawkins P, et al. Guidelines on the diagnosis and management of AL amyloidosis. *Brit J Haem* 2004;125(6).
- Storey S, Gray TF, Bryant AL. Comorbidity, physical function, and quality of life in older adults with acute myeloid leukemia. *Curr Geri Repo* 2017;6(4):247-54. <https://doi.org/10.1007/s13670-017-0227-8>
- Deschler B, de Witte T, Mertelsmann R, et al. Treatment decision-making for older patients with high-risk myelodysplastic syndrome or acute myeloid leukemia: problems and approaches. *Haem* 2006;91(11):1513-22.
- Brunner AM, Campigotto F, Sadrzadeh H, et al. Trends in all-cause mortality among patients with chronic myeloid leukemia: Asurveillance, epidemiology, and end results database analysis. *Canc* 2013;119(14):2620-9. <https://doi.org/10.1002/cncr.28106>
- Bailey C, Richardson LC, Allemanni C, et al. Adult leukemia survival trends in the United States by subtype: A population-based registry study of 370, 994 patients diagnosed during 1995-2009. *Canc* 2018;124(19):3856-67. <https://doi.org/10.1002/cncr.31674>
- Baldomero H, Neumann D, Hamad N, et al. The role of registries in hematological disorders. *Best Prac Res Clin Haem* 2024 Jun 1;37(2):101556. <https://doi.org/10.1016/j.beha.2024.101556>
- Taylor J, Xiao W, Abdel-Wahab O. Diagnosis and classification of hematologic malignancies on the basis of genetics. *Blood J Amer Soc Hema* 2017;130(4):410-23. <https://doi.org/10.1182/blood-2017-02-734541>
- Almeida AM, Ramos F. Acute myeloid leukemia in the older adults. *Leuk Res Repo* 2016;6:1-7. <https://doi.org/10.1016/j.lrr.2016.06.001>
- Thomas X. The management and treatment of acute leukemias in the elderly population. *Exp Rev Hema* 2017;10(11):975-85. <https://doi.org/10.1080/17474086.2017.1382345>
- Klepin HD, Neuendorff NR, Larson RA, et al. Treatment of acute promyelocytic leukemia in older patients: Recommendations of an International Society of Geriatric Oncology (SIOG) task force. *J Geri Onco* 2020;11(8):1199-209. <https://doi.org/10.1016/j.jgo.2020.03.019>
- Teixeira A, Carreira L, Abalde-Cela S, et al. Current and emerging techniques for diagnosis and MRD detection in AML: A comprehensive narrative review. *Canc* 2023;15(5):1362. <https://doi.org/10.3390/cancers15051362>
- Merli F, Mammi C, Ilariucci F. Integrating oncogeriatric tools into the management of chronic lymphocytic leukemia: Current state of the art and challenges for the future. *Curr Onco Repo* 2015;17(7):31. <https://doi.org/10.1007/s11912-015-0454-0>
- Presley CJ, Krok-Schoen JL, Wall SA, et al. Implementing a multidisciplinary approach for older adults with cancer: Geriatric oncology in practice. *Bmc Geri* 2020 Jul 6;20(1):231. <https://doi.org/10.1186/s12877-020-01625-5>
- Gatta B, LeBlanc TW. Palliative care in hematologic malignancies: A multidisciplinary approach. *Expert Rev Hema* 2020;13(3):223-31. <https://doi.org/10.1080/17474086.2020.1728248>
- Goede V, Stauder R. Multidisciplinary care in the hematology clinic: Implementation of geriatric oncology. *J Geri Onco* 2019;10:497-503. <https://doi.org/10.1016/j.jgo.2018.09.003>
- Parekh AK, Goodman RA, Gordon C, et al. Interagency workgroup on multiple chronic conditions. managing multiple chronic conditions: A strategic framework for improving health outcomes and quality of life. *Public Health Repo* 2011;126(4):460-71. <https://doi.org/10.1177/003335491112600403>
- Hu C, Chen W, Zhang P, et al. Global, regional, and national burden of leukemia: Epidemiological trends analysis from 1990 to 2021. *PloSOne* 2025;20(6):e0325937. <https://doi.org/10.1371/journal.pone.0325937>
- Medeiros BC, Satram-Hoang S, Hurst D, et al. Big data analysis of treatment patterns and outcomes among elderly acute myeloid leukemia patients in the United States. *Anna Hema* 2015;94(7):1127-38. <https://doi.org/10.1007/s00277-015-2351-x>
- Booth CM, Karim S, Mackillop WJ. Real-world data: Towards achieving the achievable in cancer care. *Nat Rev Clin Onco* 2019;16(5):312-25. <https://doi.org/10.1038/s41571-019-0167-7>
- Miranda-Filho A, Piñeros M, Ferlay J, et al. Epidemiological patterns of leukaemia in 184 countries: A population-based study. *Lanc Haem* 2018;5(1):e14-24. [https://doi.org/10.1016/S2352-3026\(17\)30232-6](https://doi.org/10.1016/S2352-3026(17)30232-6)
- Stubbins RJ, Stamenkovic M, Roy C, et al. Incidence and socioeconomic factors in older adults with acute myeloid leukaemia: Real-world outcomes from a population-based cohort. *Euro J Haem* 2022;108(5):437-45. <https://doi.org/10.1111/ejh.13752>
- Yamamoto JF, Goodman MT. Patterns of leukemia incidence in the United States by subtype and demographic characteristics, 1997-2002. *Canc Cont* 2008;19(4):379-90. <https://doi.org/10.1007/s10552-007-9097-2>

35. Boulanger V, Schlemmer M, Rossov S, *et al.* Establishing patient registries for rare diseases: Rationale and challenges. *Pharma Med* 2020;34(3):185-90.
<https://doi.org/10.1007/s40290-020-00332-1>
36. Hageman IC, van Rooij IA, de Blaauw I, *et al.* A systematic overview of rare disease patient registries: Challenges in design, quality management, and maintenance. *Orph J Rare Dis* 2023;18(1):106.
<https://doi.org/10.1186/s13023-023-02719-0>
37. Warner JL, Jain SK, Levy MA. Integrating cancer genomic data into electronic health records. *Geno Med* 2016;8(1):113.
<https://doi.org/10.1186/s13073-016-0371-3>
38. Berger ML, Curtis MD, Smith G, *et al.* Opportunities and challenges in leveraging electronic health record data in oncology. *Futu Onco* 2016;12(10):1261-74.
<https://doi.org/10.2217/fon-2015-0043>
39. Schoenbeck KL, Flynn KE. Health-related quality of life of patients with chronic myeloid leukemia as measured by patient-reported outcomes: Current state and future directions. *Curr Hema Mali Repo* 2021;16(6):491-9.
<https://doi.org/10.1007/s11899-021-00656-y>
40. Loh KP, Abdallah M, Kumar AJ, *et al.* Health-related quality of life and treatment of older adults with acute myeloid leukemia: A young international society of geriatric oncology review paper. *Curr Hema Mali Repo* 2019 ;14(6):523-35.
<https://doi.org/10.1007/s11899-019-00552-6>
41. Obeagu EI. Advancing leukemia diagnosis and treatment: WHO-supported laboratory innovations in Africa-A narrative review. *Blood Lymph Canc: Targ Ther* 2025;47-67. <https://doi.org/10.2147/BLCTT.S518005>
42. Ehtiati S, Naeeni B, Qeysouri B, *et al.* Electrochemical biosensors in early leukemia detection. *Clin Chem Acta* 2024;562:119871.
<https://doi.org/10.1016/j.cca.2024.119871>
43. Bhatt VR. Personalizing therapy for older adults with acute myeloid leukemia: Role of geriatric assessment and genetic profiling. *Canc Treat Rev* 2019;75:52-61.
<https://doi.org/10.1016/j.ctrv.2019.04.001>
44. Sanford D, Ravandi F. Management of newly diagnosed acute myeloid leukemia in the elderly: Current strategies and future directions. *Drug Age* 2015;32(12):983-97.
<https://doi.org/10.1007/s40266-015-0309-2>
45. Shieh Y, Eklund M, Madlensky L, *et al.* Breast cancer screening in the precision medicine era: Risk-based screening in a population-based trial. *J Natio Canc Inst* 2017;109(5):290. <https://doi.org/10.1093/jnci/djw290>
46. Seo IH, Lee YJ. Usefulness of complete blood count (CBC) to assess cardiovascular and metabolic diseases in clinical settings: A comprehensive literature review. *Biomed* 2022;10(11):2697.
<https://doi.org/10.3390/biomedicines10112697>
47. Ogasawara A, Matsushita H, Tanaka Y, *et al.* A simple screening method for the diagnosis of chronic myeloid leukemia using the parameters of a complete blood count and differentials. *Clin Chem Acta* 2019;489:249-53.
<https://doi.org/10.1016/j.cca.2018.08.038>
48. Bacher U, Schnittger S, Haferlach C, *et al.* Molecular diagnostics in acute leukemias. *Clin Chem Labo Med* 2009;47(11):1333-41.
<https://doi.org/10.1515/CCLM.2009.324>
49. Breccia M, Palandri F, Luciano L, *et al.* Identification and assessment of frailty in older patients with chronic myeloid leukemia and myelofibrosis, and indications for tyrosine kinase inhibitor treatment. *Anna Hema* 2018;97(5):745-54.
<https://doi.org/10.1007/s00277-018-3258-0>
50. Haferlach T, Kern W, Schnittger S, *et al.* Modern diagnostics in acute leukemias. *Crit Rev Onco/Hema* 2005;56(2):223-34.
<https://doi.org/10.1016/j.critrevonc.2004.04.008>
51. Maaoui F, Moumni I, Arboix-Calas F, *et al.* Emotional and behavioral attitudes of Tunisian youth towards childhood leukemia: Health education and primary prevention in perspective. *BMC Pub Health* 2022;22(1):2105.
<https://doi.org/10.1186/s12889-022-14596-6>
52. Simmons RA, Cosgrove SC, Romney MC, *et al.* Health literacy: Cancer prevention strategies for early adults. *Amer J Pre Med* 2017;53(3):S73-7.
<https://doi.org/10.1016/j.amepre.2017.03.016>
53. Cordoba R, Eyre TA, Klepin HD, *et al.* A comprehensive approach to therapy of haematological malignancies in older patients. *The Lancet Haem* 2021 Nov 1;8(11):e840-52.
[https://doi.org/10.1016/S2352-3026\(21\)00241-6](https://doi.org/10.1016/S2352-3026(21)00241-6)
54. Abdul Raheem Y. Unveiling the significance and challenges of integrating prevention levels in healthcare practice. *J Pri Care Comm Health* 2023;14:21501319231186500.
<https://doi.org/10.1177/21501319231186500>
55. Chen W, Altshuler RD, Daschner P, *et al.* Older adults with cancer and common comorbidities-challenges and opportunities in improving their cancer treatment outcomes. *J Natio Canc Inst* 2024 ;116(11):1730-8.
<https://doi.org/10.1093/jnci/djae163>
56. Garg P, Malhotra J, Kulkarni P, *et al.* Emerging therapeutic strategies to overcome drug resistance in cancer cells. *Canc* 2024;16(13):2478.
<https://doi.org/10.3390/cancers16132478>
57. Labrie M, Brugge JS, Mills GB, *et al.* Therapy resistance: Opportunities created by adaptive responses to targeted therapies in cancer. *Natu Rev Canc* 2022;22(6):323-39.
<https://doi.org/10.1038/s41568-022-00454-5>
58. Aldea M, Andre F, Marabelle A, *et al.* Overcoming resistance to tumor-targeted and immune-targeted therapies. *Canc Disc* 2021;11(4):874-99.
<https://doi.org/10.1158/2159-8290.CD-20-1638>
59. Strasser R, Kam SM, Regalado SM. Rural health care access and policy in developing countries. *Ann Rev Pub Health* 2016;37(1):395-412.
<https://doi.org/10.1146/annurev-publhealth-032315-021507>
60. Epstein RM, Duberstein PR, Fenton JJ, *et al.* Effect of a patient-centred communication intervention on oncologist-patient communication, quality of life, and health care utilization in advanced cancer: the VOICE randomized clinical trial. *JAMA Oncol* 2017;3(1):92-100.
<https://doi.org/10.1001/jamaoncol.2016.4373>
61. Chahin S, Wruble L, Joshi P. Empowering care: Crafting patient-centered treatment plans for optimal outcomes. Inusing integrated behavioral health in pediatric practice: An essential guide to better outcomes and equitable care. Cham: Spri Natu Switz 2025 8:73-92.
https://doi.org/10.1007/978-3-031-85784-3_6
62. Nsubuga P, White ME, Thacker SB, *et al.* Public health surveillance: A tool for targeting and monitoring interventions.
63. Lee E, Rogers M. Cancer: leukemia and lymphoma. *Prac Clin Social Work Health* 2023;37-62.
https://doi.org/10.1007/978-3-031-31650-0_3