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The New Face of Cancer Prevention: Integrating Vaccination, Lifestyle Modification, and Genetic Risk Assessment

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Cancer prevention is undergoing a necessary conceptual shift. Prevention has been conveyed for decades as a personal behavior issue: stop smoking, eat well, exercise, avoid too much sun, and get screened [1]. Although these messages are still important, they no longer reflect the full range of possibilities for prevention. The modern prevention agenda is shaped by a growing trend of three complementary prevention strategies: vaccinating against cancer causing infections, achieving substantial and meaningful reductions in modifiable exposures, and genetic risk assessment, which can lead to earlier and more proportionate intervention [2].

The integrated model provides a more realistic pathway forward to reducing the global cancer burden [3]. Recent estimates of the global cancer burden indicate that almost 40% of new cancer cases can be prevented by potentially modifiable risk factors such as tobacco use, infections, alcohol consumption, excess body weight, physical inactivity, occupational exposures, ultraviolet radiation, and air pollution. Tobacco is still the top preventable contributing factor, followed by infections and alcohol-related exposure. The message is clear: cancer control cannot be limited to the number of cancer treatments and the ability to diagnose cancer early. It has to start well before the first abnormal cell is formed [4].

One of the strongest and underutilized weapons in the fight against cancer is vaccination. HPV vaccine has the power to make cervical cancer a thing of the past and provides protection against several HPV cancers such as anal, penile, vulval, vaginal and oropharyngeal cancers [5]. HPV vaccines are over 90% effective in preventing cancers of HPV types included in HPV vaccination programmes. Hepatitis B vaccination also helps to prevent chronic infection which may lead to cirrhosis and hepatocellular carcinoma. These interventions are particularly relevant in low- and middle-income countries where an excess proportion of cancers are caused by infection [6].

But even the availability of effective vaccines does not necessarily mean that people are protected. A major challenge is the inequity of vaccination [7]. However, in many locations HPV vaccination is hindered by low availability, high costs, poor school health systems, information gaps, cultural resistance and lack of gender-inclusive programmes. Cancer prevention policy should therefore shift from providing vaccines to working to make them accessible, trusted, and regularly delivered. Thinking of vaccination as a "public health add-on" should be abandoned, and vaccinations should be recognized as an integral method for cancer control along with screening and treatment [8].

Lifestyle modification is also essential and needs to be reworded. The idea of individual responsibility for prevention is insufficient in scientific terms, and unacceptable in moral terms, when we don't account for the environments that influence behaviour [9,10]. Tobacco dependence, unhealthy diets, alcohol consumption,

sedentary lifestyles and obesity are not just personal choices: all are affected by affordability, marketing, occupational demands, urban design, education, food systems and policy. This type of prevention such as 'live better' without providing 'how' or 'why' to make healthier choices will be useless to those who are most vulnerable [11].

The evidence points to a wide-ranging lifestyle program that includes continuing tobacco control efforts, limiting alcohol consumption, adopting healthy food habits, maintaining a healthy body weight, engaging in regular physical activity, avoiding UV exposure, and minimizing exposure to occupational and environmental carcinogens [12,13]. New advice on cancer prevention from the international community has again stressed the avoidance of tobacco use, maintaining a healthy weight, physical exercise, diet, reducing alcohol intake, protecting against the sun, and preventing virus-induced cancers. But the most successful interventions are often structural: smoke-free laws, tobacco taxation, curbing marketing, increasing availability of healthy foods, providing safe environments for physical activity, and bringing vaccines to schools, as well as alcohol and environmental carcinogen controls [14].

The third pillar, genetic risk assessment, could help individualise prevention without compromising population-based interventions [15]. The discovery of pathogenic variants in the high penetrance cancer susceptibility genes have already changed prevention for those at risk, or within families for hereditary breast, ovarian, colorectal, prostate, pancreatic and other cancers. Intensified surveillance and or risk-reducing medications, imaging and surgery, and cascade testing of families can all be directed by appropriate genetic counselling and testing. Significantly, inherited susceptibilities do not mean doom and gloom. Genetic information will identify vulnerability; it will not remove the importance of prevention, screening or healthy behaviours [16].

Polygen risk scores could also be used to improve the risk stratification by aggregating many common genetic variants into an individual's inherited risk [17]. Their potential value is related to identifying those individuals who could benefit from earlier, more frequent or more customized screening. For instance, recent studies suggest that breast cancer risk models could be improved by use of polygenetic scores and that this could change screening recommendations for an important minority of women. However, caution needs to be coupled with enthusiasm. Polygenic risk scores are not similarly valid across ancestral groups, could exacerbate inequities if based primarily on European-ancestry data, and should be clinically interpreted. While they offer promise, the evidence is current and there is an absence of indiscriminate implementation [18].

The central issue is not one of universal prevention vs personalised prevention. It is to make a smart integration [19]. Together with targeted genetic counselling, universal HPV and hepatitis B vaccination should be implemented. Tobacco-control laws should be used in combination with individual tobacco cessation assistance. The population level steps on improving diet and increasing physical activity should be complemented by more aggressive screening of these who are at higher inherited or familial risk. Prevention must be considered a continuum including reducing exposure, preventing infection, identifying susceptibility, early detection of disease, and equitable access to intervention [20].

But health systems should also be wary of making precision prevention the exclusive domain of the wealthy. Genetic testing without counselling, commercial risk scores without validated pathways, and screening recommendations without accessible follow-up, can raise anxiety without better outcomes. Precision prevention needs to be based on evidence, culturally relevant, clearly communicated, and integrated into health systems and not positioned as a stand-alone biomedical product [21,22].

So the new face of cancer prevention is not entirely behavioural, it's not entirely technological. It's more population-based and precision based as well as collective and individual [23]. Vaccination against preventable infection-related cancers, lifestyle and policy measures to limit exposure to known carcinogens and genetic risk assessment to target more aggressive preventive measures. These approaches provide a way to shift cancer control upstream from treating cancer once it develops to preventing cancer before it occurs [24].

The future of cancer prevention will not be determined only by new drugs, sophisticated imaging, or genomic innovation. It will be determined by whether health systems and governments can deliver the prevention tools already available, equitably and at scale [25].

CONCLUSION

Cancer prevention needs to be more than stand-alone advice and disjointed programmes. Vaccination against oncogenic infections, lifelong lifestyle changes and appropriate genetic risk assessment will minimize preventable cancers and allow for earlier, more personalized, intervention. Translating this integrated approach to prevention to benefit at the population level will require equitable access, robust public-health policy and responsible use of genomic tools.

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