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Modelling and artificial intelligence to support vaccination planning, vaccine research and public guidance

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Background. Vaccination contributes to infection prevention and antimicrobial resistance control. Translating evidence into vaccination strategies requires tools to explore alternative scenarios, identify research priorities and communicate recommendations. We present three complementary approaches addressing these needs.

Materials and Methods. SIVax is an age-structured mechanistic framework for generating synthetic influenza epidemic curves, epidemiological calibration and evaluation of alternative vaccination scenarios, informed by 16 pre-COVID-19 Italian surveillance seasons. A compartmental model of methicillin-resistant Staphylococcus aureus (MRSA), calibrated to Italian ECDC infection estimates for 2016-2020, explores hypothetical vaccine characteristics and transmission conditions. VaccinIAmoci is a conversational artificial intelligence system grounded in Italian institutional vaccination guidance and constrained to vaccination-related queries. Two domain experts independently evaluated its responses to 180 queries against a generic-prompt baseline.

Results. SIVax enabled exploration of how campaign timing and age-specific coverage could influence influenza incidence, while making calibration uncertainty and scenario assumptions explicit. The MRSA model provided conditional vaccine performance benchmarks, highlighting the importance of protection against acquisition and the constraints imposed by external reservoirs. VaccinIAmoci improved response accuracy and rejection of off-topic requests compared with the generic prompt, although residual errors concerned pregnancy and travel health. These findings illustrate distinct uses of modelling and artificial intelligence in vaccination planning, vaccine research and public communication.

Conclusions. These approaches can make complex evidence more accessible for scenario analysis, research prioritisation and vaccination guidance. Their value depends on transparent assumptions, explicit uncertainty and appropriate validation. Model outputs represent conditional scenarios rather than forecasts or deployment thresholds, while chatbot performance requires real-world evaluation before conclusions can be drawn about vaccination uptake or health outcomes.