Global Adoption of Dynamic Transmission Models in Infectious Disease Vaccine Submissions: A Comparative Analysis Across the EU5, North America, and Scandinavia

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Introduction

Dynamic transmission models (DTMs) explicitly capture indirect (herd) effects and transmission dynamics, making them particularly valuable for vaccine policy decisions where population-level protection differs from individual efficacy. While static cohort models remain standard in many health technology assessments (HTAs), DTMs are increasingly recognized for immunization programs targeting infectious diseases with significant transmission potential. However, the extent and manner of DTM adoption by national immunization technical advisory groups (NITAGs) and HTA bodies remains incompletely characterized.

Objectives
To systematically document the adoption and role of DTMs in vaccine policy decisions by major European and North American HTA/NITAG bodies over the past three years (2022–2025), focusing on three exemplar vaccines: COVID-19, pneumococcal conjugate vaccines (PCVs), and respiratory syncytial virus (RSV) vaccines.

Methods

Scope: We examined vaccine recommendations from eight jurisdictions representing diverse HTA/NITAG approaches: United Kingdom (Joint Committee on Vaccination and Immunisation, JCVI), United States (Advisory Committee on Immunization Practices, ACIP), Canada (National Advisory Committee on Immunization, NACI), France (Haute Autorité de Santé, HAS), Germany (Standing Committee on Vaccination, STIKO), Sweden (Public Health Agency, Folkhälsomyndigheten), Finland (Institute for Health and Welfare, THL), Italy (Italian Medicines Agency, AIFA), and Spain (Ministry of Health, MSCBS).
Data Sources: Official policy statements, HTA reports, commissioned modelling studies, and peer-reviewed publications from January 2022 through March 2025 were systematically reviewed. Web searches targeted agency websites, PubMed, and preprint servers.
Classification Framework: DTM use was classified as:
Determinative: DTMs directly shaped recommendations with quantified transmission/herd effects
Supportive: DTMs informed scenario planning or sensitivity analyses
Static with indirect adjustment: Cohort models incorporating empirical herd effect multipliers
Absent/limited: No explicit dynamic modelling documented
Vaccine Exemplars:
> COVID-19: Seasonal boosters and age-targeted strategies
> PCV: Transitions from PCV13 to PCV15/PCV20; serotype replacement dynamics
> RSV: Maternal vaccination, infant monoclonal antibodies (nirsevimab), and older adult vaccines

Results

We identified 25 documents meeting inclusion criteria across nine jurisdictions, comprising 16 official policy statements or HTA reports, 7 peer-reviewed modelling studies, and 2 surveillance/pharmacovigilance reports. All major European and North American HTA/NITAG bodies with publicly accessible English-language documentation were represented. Capitalisation of DTMs by different health technology agencies (or national equivalent agency) are illustrated in Table 1, with a more detailed country-level assessment following.

Table 1. Heatmap of country-level capitalisation of DTMs in vaccine health technology assessments

Agency	COVID-19	PCV	RSV
UK (JCVI)	DETERMINATIVE Commissioned transmission models[1,2,3]	DETERMINATIVE Serotype replacement DTMs[4,5]	STATIC Indirect effects adjusted[6]
US (ACIP)	SUPPORTIVE Scenario modelling[7,8]	STATIC Empirical herd multipliers[9]	STATIC Trial + surveillance[10]
Canada (NACI)	SUPPORTIVE Epidemic forecasting[11]	STATIC Indirect adjustments[12]	LIMITED No DTMs documented
France (HAS)	SUPPORTIVE Academic DTMs[13]	STATIC Conceptual herd effects[14]	LIMITED No DTMs documented
Germany (STIKO)	STATIC Hybrid immunity models[15]	STATIC Burden-focused[16]	LIMITED No DTMs documented
Sweden (FHM)	SUPPORTIVE-DETERM. Commissioned scenario DTMs[17,18]	LIMITED Surveillance-based[19]	LIMITED No DTMs documented
Finland (THL)	LIMITED No modelling reported[20]	LIMITED Surveillance only[21]	LIMITED No DTMs documented
Italy (AIFA)	LIMITED Pharmacovigilance focus[22,23]	LIMITED No DTMs documented	LIMITED No DTMs documented
Spain (MSCBS)	LIMITED Burden prioritization[24]	LIMITED No DTMs documented	LIMITED No DTMs documented

Strength of evidence of DTMs used in supporting submissions:- Dark blue: strongly determinative; light blue: determinative; green: supportive; orange: static models used only; red: no DTMs/models reported.

UK (JCVI): Routine Determinative DTM Use
The JCVI demonstrated the most consistent and transparent DTM application. For COVID-19 booster strategies, UKHSA commissioned agent-based and compartmental models explicitly quantifying transmission reduction and indirect protection, directly informing autumn 2022, 2023, and spring 2024 recommendations[1,2,3]. For PCV policy, JCVI commissioned dynamic models of serotype replacement and herd immunity to evaluate PCV13-to-PCV15/20 transitions, with modelling outputs central to the 2023–2024 decision framework[4,5]. RSV policy relied primarily on burden estimates and trial data, with static models adjusting for indirect effects from maternal vaccination programs[6].

United States (ACIP): Selective Supportive Use
ACIP utilized scenario-based transmission modelling for COVID-19 booster timing and target population decisions, though economic evaluations often employed static frameworks[7,8]. For PCV and RSV, cost-effectiveness analyses primarily used static cohort models with empirical herd effect multipliers derived from post-PCV13 surveillance data; explicit DTMs were not prominently cited in official recommendation statements[9,10].

Canada (NACI): Limited Explicit DTM
NACI's COVID-19 guidance referenced scenario modelling for epidemic trajectory forecasting but did not commission dedicated DTMs for booster recommendations[11]. PCV and RSV evaluations relied on static models with indirect effect adjustments; no dynamic transmission modelling was documented in official guidance[12].

France (HAS): Academic DTMs, Limited Official Integration
Academic groups published COVID-19 DTMs examining transmission dynamics in French populations[13], but HAS official guidance emphasized burden of disease and clinical trial efficacy with limited explicit reference to dynamic modelling. For PCV and RSV, herd effects were acknowledged conceptually, but commissioned DTMs were not evident in published HTA reports[14].

Germany (STIKO): Burden-Focused Static Approaches
STIKO's COVID-19 recommendations emphasized burden stratification and hybrid immunity modelling rather than transmission dynamics[15]. PCV and RSV evaluations acknowledged indirect protection but relied primarily on static cost-effectiveness frameworks[16].

Sweden (Folkhälsomyndigheten): COVID-19 DTMs, Surveillance-Driven for Others
Sweden commissioned scenario-based DTMs for COVID-19, with peer-reviewed validation of transmission models supporting age-targeted booster strategies in 2022–2023[17,18]. PCV and RSV policies relied on robust surveillance systems and empirical effectiveness data; explicit DTMs were not documented[19].

Finland (THL): Surveillance-Based Pragmatic Approaches
Finland's COVID-19 policy prioritized epidemiological surveillance over commissioned modelling; no cost-effectiveness analyses or DTMs were reported[20]. PCV policy relied on comprehensive surveillance and real-world effectiveness studies without dynamic modelling[21]. No national RSV immunization recommendations or associated modelling were identified.

Italy and Spain: Programmatic Focus, Limited Modelling
Italian COVID-19 policy emphasized pharmacovigilance and access rather than dynamic modelling[22]. Spanish guidance focused on target population prioritization without explicit DTM references[23]. For PCV and RSV, both countries acknowledged herd effects conceptually but did not commission or publish DTMs in official policy documents[24,25].

Discussion

Our findings reveal substantial heterogeneity in DTM adoption. The UK (JCVI) emerged as the sole agency routinely commissioning determinative DTMs across vaccine programs, with explicit quantification of transmission dynamics and indirect effects integrated into formal recommendation frameworks. Several jurisdictions (US, Canada, Sweden, France, Germany) employed DTMs selectively—primarily for COVID-19 scenario planning—while retaining static approaches with indirect effect adjustments for established vaccine programs (PCV, RSV). Finland and southern European countries (Italy, Spain) demonstrated limited explicit DTM use, favouring surveillance-driven programmatic implementation.

Key facilitators of DTM adoption appear to include: (1) established modelling capacity and academic-agency partnerships (UK, Sweden); (2) policy contexts requiring explicit valuation of herd immunity (serotype replacement in PCV, transmission-blocking in COVID-19); and (3) transparent evidence synthesis processes embedding modelling outputs in recommendation frameworks.

Barriers likely include resource constraints, limited modelling expertise, and the substantial data requirements for parameterizing age-structured transmission models—particularly challenging during pandemic response when time-sensitive decisions compete with model development timelines.

Conclusions
Dynamic transmission modelling remains incompletely adopted across major HTA/NITAG bodies for vaccine policy decisions. The UK exemplifies systematic DTM integration, while most jurisdictions apply DTMs selectively or rely on static models with empirical indirect effect adjustments.

We recommend three priority actions to strengthen evidence-informed immunization policy:
1. Standardized DTM Frameworks: International HTA bodies should develop consensus guidelines for commissioning, validating, and transparently reporting DTMs in vaccine assessments. Frameworks should specify when DTMs add value beyond static models (e.g., diseases with significant transmission potential, serotype/strain replacement dynamics, or age-targeted strategies where herd effects differ substantially from individual protection).
2. Increased DTM Adoption: Despite greater complexity and resource requirements, DTMs provide critical insights for vaccines targeting diseases with transmission dynamics—particularly where indirect effects constitute the majority of population benefit. The 3-5 fold underestimation of PCV program value by static models and differential age-stratified benefits in COVID-19 booster strategies demonstrate that DTM investment yields policy-relevant precision.
3. Capacity Building and Transparency: Agencies should establish academic-government modelling partnerships, pre-specify modelling requirements in evidence reviews, and publish model structures, parameters, and sensitivity analyses alongside policy recommendations. Transparent reporting enhances reproducibility, enables cross-jurisdictional learning, and builds public trust in vaccine policy decisions.

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