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Supplementary information

Chinese innovative drug R&D trends in 2024

In the format provided by the authors and unedited

Supplementary Box 1 | Data and analysis

The data on China's domestic novel drug pipelines were gathered from the Pharmcube database, which compiles information from a variety of sources, including China's Registration and Information Disclosure Platform for Drug Clinical Studies, Chinese Clinical Trial Register (ChiCTR), ClinicalTrials.gov clinical trial registries, scientific conferences, company press releases, published reports and investor presentations, among others.

Our analysis included investigational therapeutics and vaccines aimed at treating or preventing diseases, excluding generic drugs or biosimilars. The included products were either discovered de novo in China or were products that were in-licensed by Chinese companies that entered clinical development but had not received marketing authorization in any country by 1 January 2024. Products no longer being actively developed were excluded. A total of 4,391 candidates were included in this analysis.

To track the evolution of China's innovative drug landscape, we performed a comprehensive comparison between the data for the current analysis (with a data cut-off of 1 January 2024) and the data for our previous analysis[1] (with a data cut-off of 1 July 2021). Following methods similar to the previous analysis[1], data were manually verified and categorized according to parameters of target, product type, innovation level, most advanced development stage for any indication in China and abroad, indications, and location of origin. Some product information might not be publicly available, which could affect the classification of individual products.

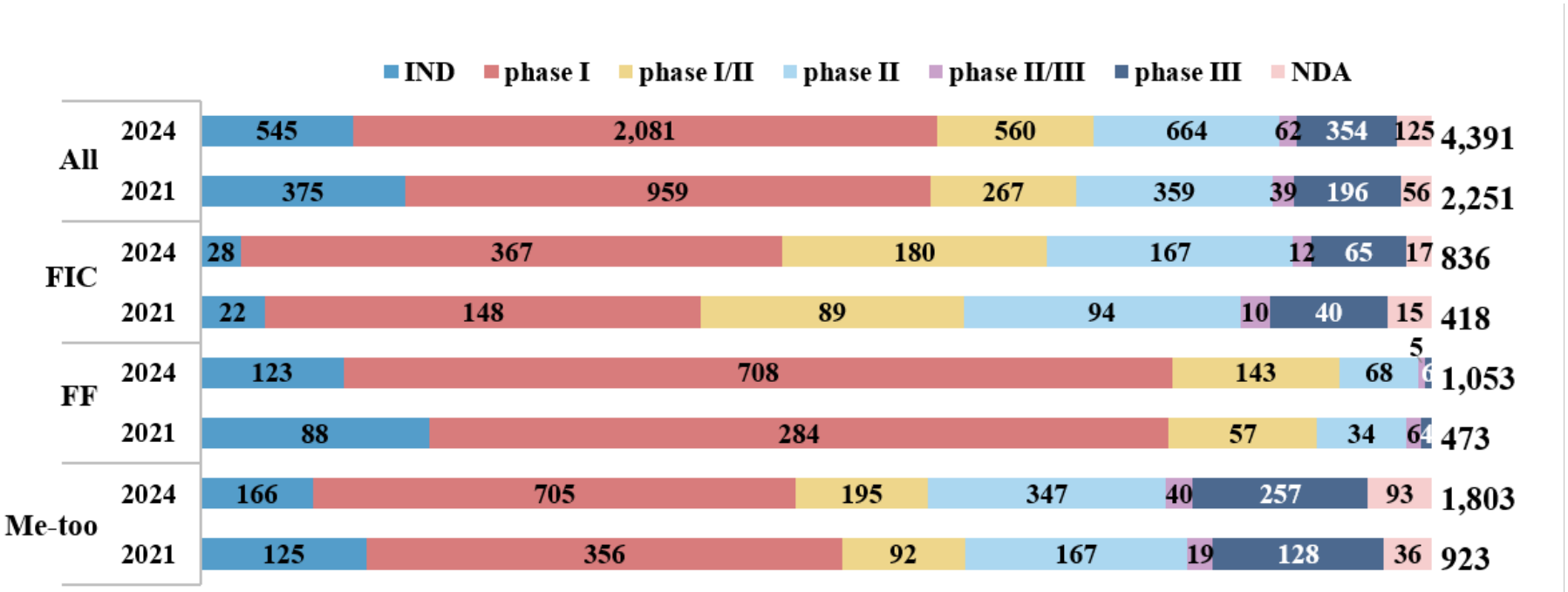
In terms of product type, candidates were initially classified as small molecules, monoclonal antibodies (mAbs), recombinant proteins, vaccines (prophylactic and therapeutic, but excluding dendritic cell therapies and nucleic acid-based vaccines), next-generation agents, and others (for agents unclassifiable into the aforementioned categories) or not available (for agents unclassifiable due to insufficient information). For next-generation agents, nine subgroups were identified, including cell therapies, bispecific or multi-specific antibodies, antibody–drug conjugates (ADCs), gene therapies, oncolytic viruses, nucleic acid-based therapies, proteolysis-targeting chimeras (PROTACs), nucleic acid-based vaccines and other next-generation drugs. The origins of drugs were categorized as discovered in-house or in-licensed. Products developed in-house could additionally be classified into the out-licensed group. Indications were grouped into therapeutic areas such as oncology (including haematologic cancers), infectious diseases, endocrine and metabolic diseases, autoimmune and immunologic diseases, cardiovascular diseases, neurologic diseases, gastrointestinal diseases, respiratory diseases, psychiatric diseases, dermatologic diseases, ophthalmologic diseases, haematologic diseases (non-oncology) and others (including therapeutic areas featuring fewer than 20 products, such as otologic diseases).

Regarding innovation level, therapies were classified into three groups: first-in-class, fast-follower and me-too, based on their targets, mechanisms of action (MoAs) and the most advanced development stages compared to global counterparts. Drugs with novel targets or novel MoAs were defined as either first-in-class or fast-follower based on whether or not

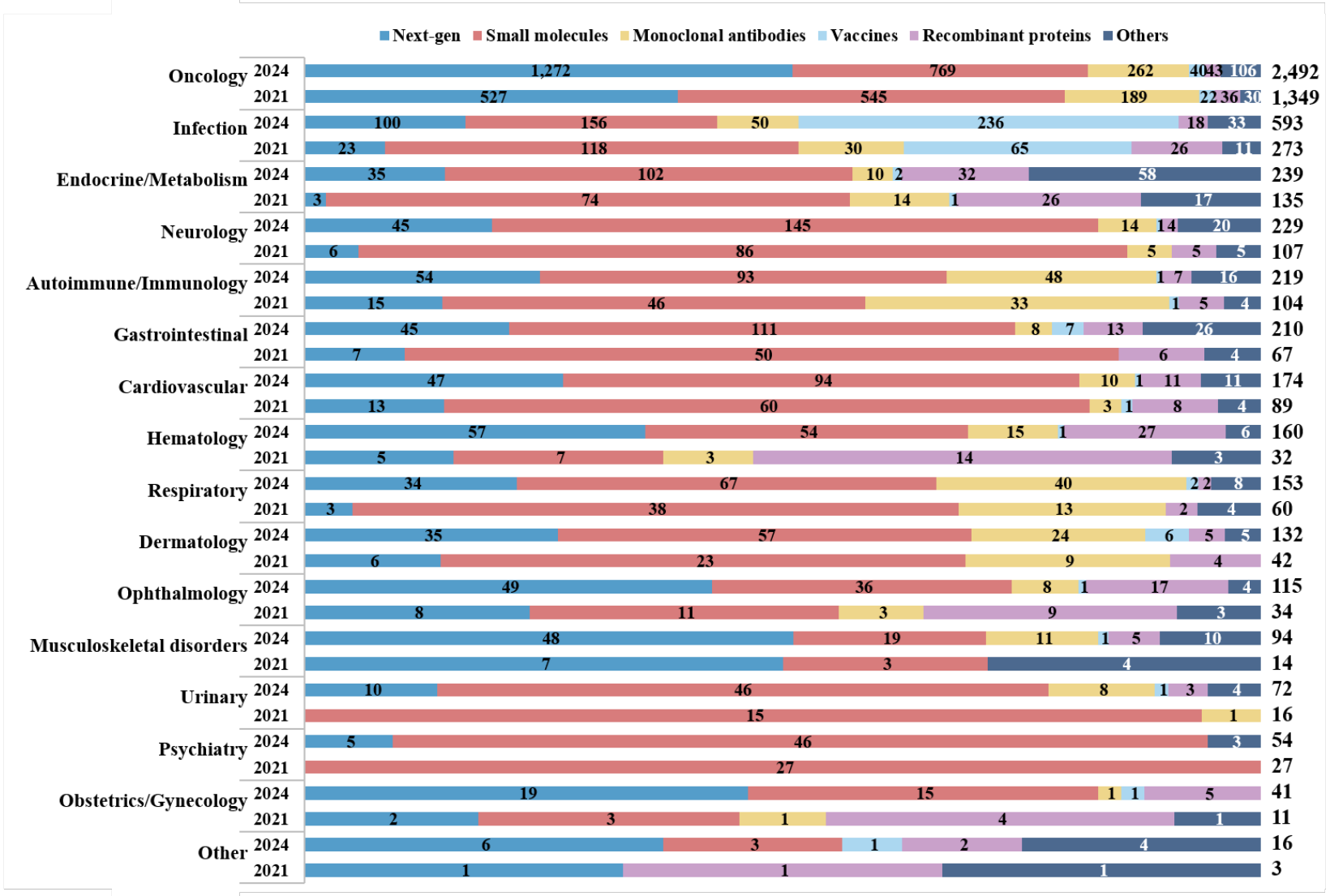
they have class-leading clinical development status worldwide, respectively. Drugs with the same targets and similar MoAs as already-approved drug classes were considered me-too. It is noteworthy that the innovation level of the same products can differ between 2021 and 2024, depending on the product's R&D pace relative to similar products, the level of detail in information disclosure, and whether new mechanisms of action have been identified. For example, 32 me-too agents identified in 2021 were reclassified as first-in-class or fast-follower in the 2024 dataset due to the identification of novel mechanisms of action for these products. First-in-class products at the phase III or new drug application stage are listed in Supplementary Table 1.

Reference

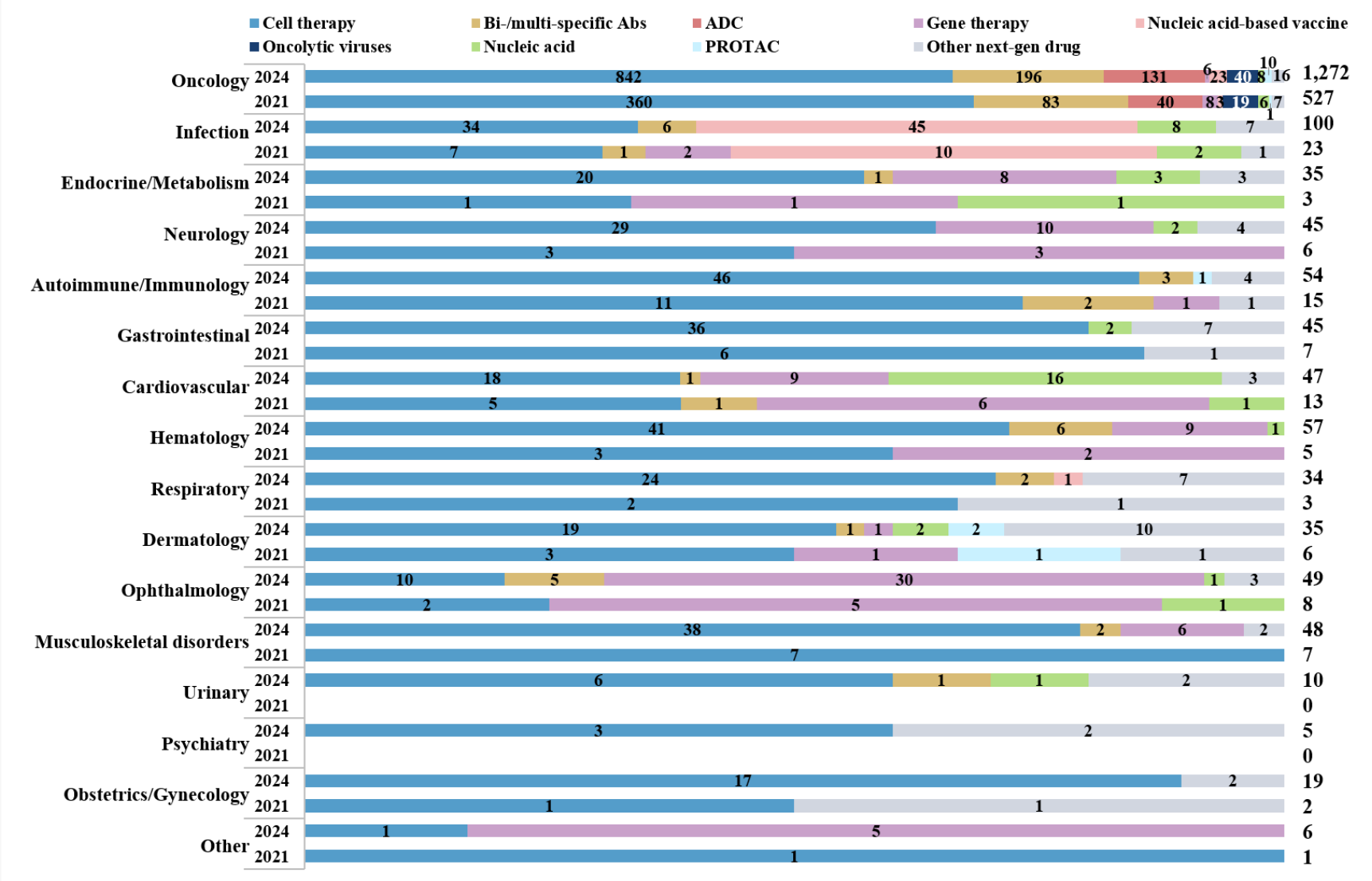
1. Li G, Liu Y, Hu H, Yuan S, Zhou L, Chen X. Evolution of innovative drug R&D in China. *Nat. Rev. Drug Discov.* **21**, 553-554 (2022).



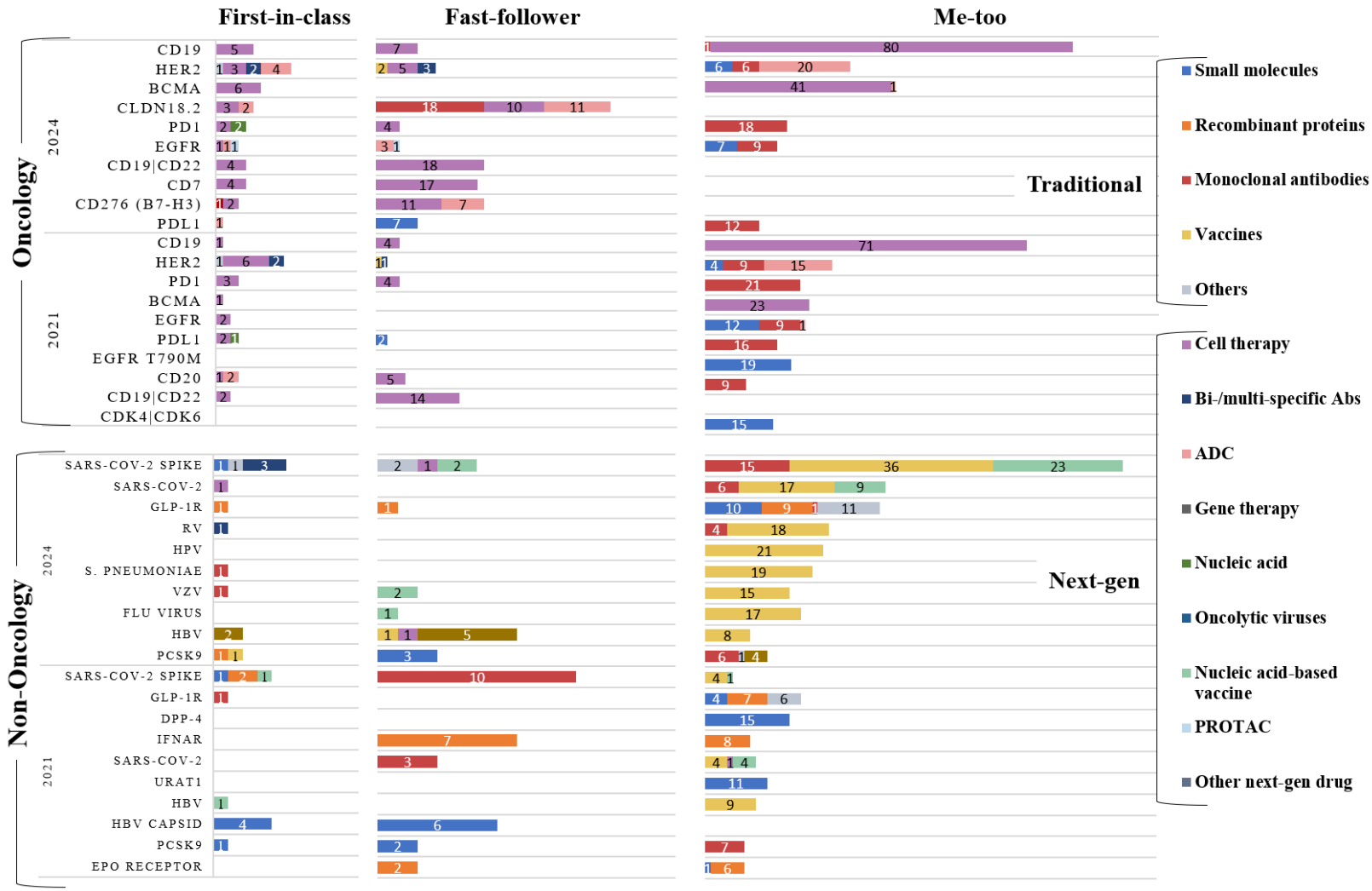
Supplementary Fig. 1 | Overview of most advanced development status of the investigational drug pipeline in China in 2021 and 2024 by innovation level. The products were grouped by innovation level (FIC, first-in-class; FF, fast-follower; me-too) and most advanced development status globally. IND, in the process of Investigational New Drug (IND) application; NDA, in the process of New Drug Application (NDA). Agents unamenable to classification into FIC, FF and me-too were only included in 'All' group.


Next-gen
Small molecules
Monoclonal antibodies
Vaccines
Recombinant proteins
Others
Oncology 2024 1,272 769 262 40 43 106 2,492
2021 527 545 189 22 36 30 1,349
Infection 2024 100 156 50 236 18 33 593
2021 23 118 30 65 26 11 273
Endocrine/Metabolism 2024 35 102 10 2 32 58 239
2021 3 74 14 1 26 17 135
Neurology 2024 45 145 14 14 20 229
2021 6 86 5 5 5 107
Autoimmune/Immunology 2024 54 93 48 1 7 16 219
2021 15 46 33 1 5 4 104
Gastrointestinal 2024 45 111 8 7 13 26 210
2021 7 50 6 4 67
Cardiovascular 2024 47 94 10 1 11 11 174
2021 13 60 3 1 8 4 89
Hematology 2024 57 54 15 1 27 6 160
2021 5 7 3 14 3 32
Respiratory 2024 34 67 40 2 2 8 153
2021 3 38 13 2 4 60
Dermatology 2024 35 57 24 6 5 5 132
2021 6 23 9 4 42
Ophthalmology 2024 49 36 8 1 17 4 115
2021 8 11 3 9 3 34
Musculoskeletal disorders 2024 48 19 11 1 5 10 94
2021 7 3 4 14
Urinary 2024 10 46 8 1 3 4 72
2021 15 1 16
Psychiatry 2024 5 46 3 54
2021 27 27
Obstetrics/Gynecology 2024 19 15 1 1 5 41
2021 2 3 1 4 1 11
Other 2024 6 3 1 2 4 16
2021 1 1 1 3

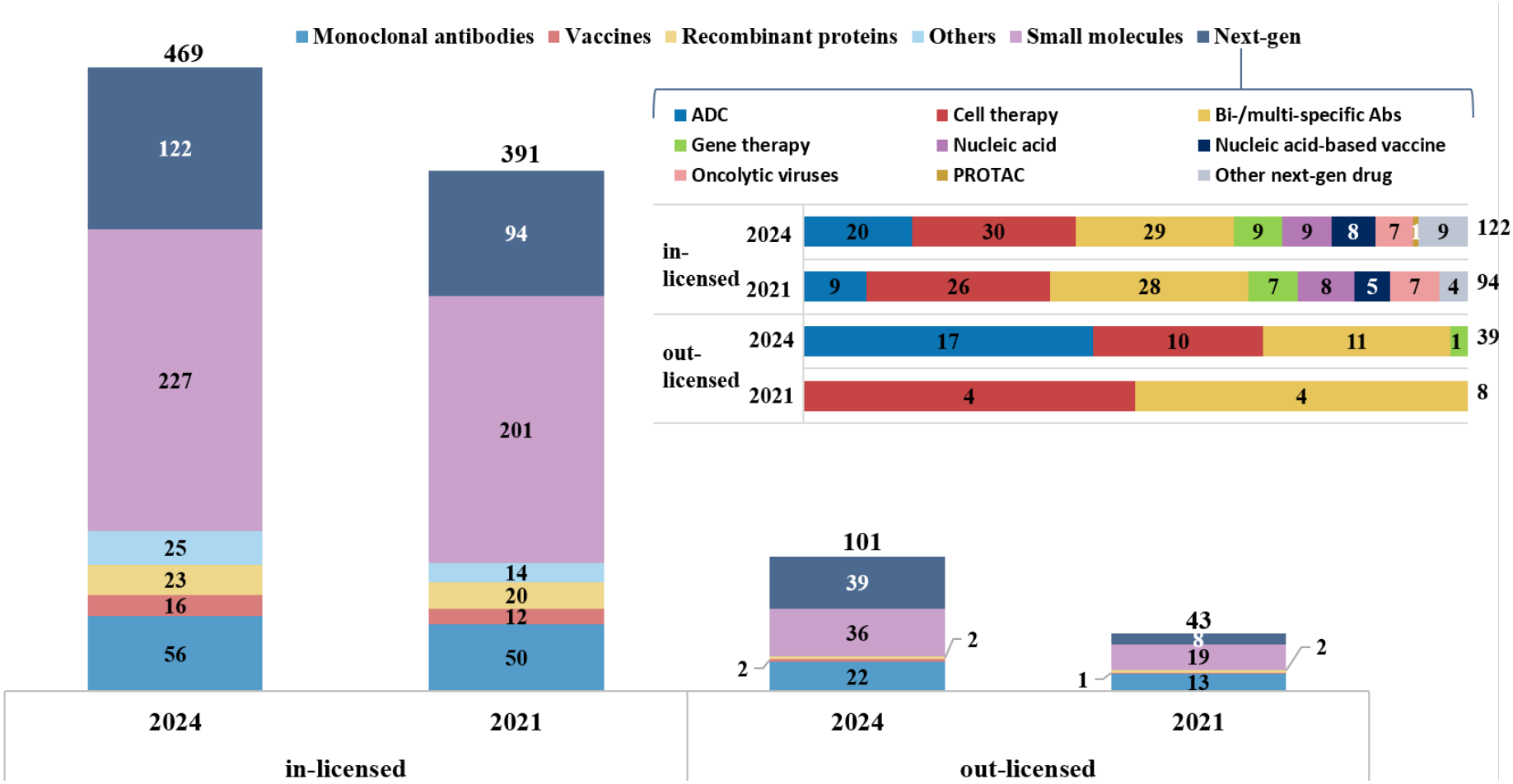
Supplementary Fig. 2 | Overview of agents with different product types by therapeutic areas. The agents were classified into five main groups: next-generation agents (next-gen), small molecules, monoclonal antibodies, recombinant proteins, and vaccines. Those not aligning with these categories were placed in an ‘Others’ group. Additionally, these agents were grouped by various therapeutic areas. Therapeutic areas featuring fewer than 20 products, such as otology, and agents that could not be classified due to insufficient information or did not align with the main therapeutic areas, were grouped into an 'Other' category. A single drug product with multiple indications could be counted in more than one therapeutic area.


Cell therapy
Bi-/multi-specific Abs
ADC
Gene therapy
Nucleic acid-based vaccine
Oncolytic viruses
Nucleic acid
PROTAC
Other next-gen drug
Oncology 2024 842 196 131 6 23 40 8 10 16 1,272
2021 360 83 40 83 19 6 7 1 527
Infection 2024 34 6 45 8 7 100
2021 7 1 2 10 2 1 23
Endocrine/Metabolism 2024 20 1 8 3 3 35
2021 1 1 1 3
Neurology 2024 29 10 2 4 45
2021 3 3 6
Autoimmune/Immunology 2024 46 3 1 4 54
2021 11 2 1 1 15
Gastrointestinal 2024 36 2 7 45
2021 6 1 7
Cardiovascular 2024 18 1 9 16 3 47
2021 5 1 6 1 13
Hematology 2024 41 6 9 1 57
2021 3 2 5
Respiratory 2024 24 2 1 7 34
2021 2 1 3
Dermatology 2024 19 1 1 2 2 10 35
2021 3 1 1 1 6
Ophthalmology 2024 10 5 30 1 3 49
2021 2 5 1 8
Musculoskeletal disorders 2024 38 2 6 2 48
2021 7 7
Urinary 2024 6 1 1 2 10
2021 0
Psychiatry 2024 3 2 5
2021 0
Obstetrics/Gynecology 2024 17 2 19
2021 1 1 2
Other 2024 1 5 6
2021 1 1

Supplementary Fig. 3 | Overview of next-generation agents by different therapeutic areas. The next-generation agents were classified into eight main groups (cell therapies, bi- or multi-specific antibodies (Abs), antibody–drug conjugates (ADCs), gene therapies, oncolytic virus, nucleic acid, proteolysis-targeting chimeras (PROTACs) and nucleic acid-based vaccines). Those not aligning with these categories were placed in an ‘Other next-generation drug’ group. Additionally, these agents were grouped by various therapeutic areas. Therapeutic areas featuring fewer than 20 products, such as otology, and agents that could not be classified due to insufficient information or did not align with the main therapeutic areas, were grouped into an 'Other' category. A single drug product with multiple indications could be counted in more than one therapeutic area.


First-in-class
Fast-follower
Me-too
Oncology
2024
CD19
HER2
BCMA
CLDN18.2
PD1
EGFR
CD19|CD22
CD7
CD276 (B7-H3)
PDL1
2021
CD19
HER2
PD1
BCMA
EGFR
PDL1
EGFR T790M
CD20
CD19|CD22
CDK4|CDK6
Traditional
Non-Oncology
2024
SARS-COV-2 SPIKE
SARS-COV-2
GLP-1R
RV
HPV
S. PNEUMONIAE
VZV
FLU VIRUS
HBV
PCSK9
2021
SARS-COV-2 SPIKE
GLP-1R
DPP-4
IFNAR
SARS-COV-2
URAT1
HBV
HBV CAPSID
PCSK9
EPO RECEPTOR
Next-gen
Small molecules
Recombinant proteins
Monoclonal antibodies
Vaccines
Others
Cell therapy
Bi-/multi-specific Abs
ADC
Gene therapy
Nucleic acid
Oncolytic viruses
Nucleic acid-based vaccine
PROTAC
Other next-gen drug

Supplementary Fig. 4 | Top ten targets of oncology and non-oncology agents in the investigational drug pipeline in 2021 and 2024. Agents were classified based on their innovation level as in Fig. 1 and by product type, and the figure is an expanded version of Fig. 2. Agents engaging multiple targets are indicated by a '/' symbol (such as CD19/CD22). Ab, antibody; RV, rabies virus; HPV, human papilloma virus; HBV, hepatitis B virus; VZV, varicella-zoster virus; CD, cluster of differentiation; CDK, cyclin-dependent kinase; EGFR, epidermal growth factor receptor; HER, human epidermal growth factor receptor; PCSK9, proprotein convertase subtilisin/kexin type 9; PD1, programmed cell death 1; PDL1,programmed death-ligand 1; BCMA, B-cell maturation antigen; URAT1, urate transporter; DPP-4, dipeptidyl peptidase-4; S. pneumoniae, *Streptococcus pneumoniae*.



Supplementary Fig. 5 | Characteristics of in-licensed and out-licensed agents. The agents were classified into five main groups: small molecules, monoclonal antibodies (mAbs), recombinant proteins, vaccines, and next-generation agents (next-gen). Agents not fitting into the main groups were included in an 'Others' group. Subgroups of next-gen agents are depicted in doughnut charts, including cell therapies, bispecific or multi-specific antibodies, antibody–drug conjugates (ADCs), gene therapies, oncolytic virus, nucleic acid-based, proteolysis-targeting chimeras (PROTACs), nucleic acid-based vaccines and other next-generation drugs that do not fit into the aforementioned categories.