

Landscape Review and Economic Potential of the Oncology and Allied Digital Health Sector on the Island of Ireland

APRIL 2024



ALL-ISLAND ONCOLOGY INDUSTRY REPORT

Information Note



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This report is the result of an All-Island Cancer Research Institute (AICRI) initiative supported by InterTradeIreland's Synergy programme. It is based on data analysis, stakeholder interviews, and desk research.

Participation from all the stakeholders in the interviews is gratefully acknowledged.

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Foreword

The All-Island Cancer Research Institute (AICRI) is bringing together and amplifying the combined expertise of cancer researchers and other stakeholders across the island of Ireland, linking with US and other international partners in order to tackle the increasing burden of cancer (www.aicri.org). Its core mission is to provide an overarching framework for cancer research and associated innovation across the island of Ireland, from discovery to implementation, for the benefit of cancer patients and wider society.

A primary focus for AICRI is to deepen North-South collaboration in research and innovation and strengthen societal and economic links for mutual benefit. In this context, major funding was awarded in 2022 under the Higher Education Authority (HEA) North-South Research Programme, a collaborative scheme supported through the Shared Island Initiative, to kick-start the development of AICRI in the areas of PhD and post-doctoral training and research in precision cancer medicine, digital health and liquid biopsies. A key aspect of AICRI's activities is to bring multiple stakeholders together, including the industry sector, so as to ensure the broader cancer research and innovation ecosystem on the island of Ireland is both defined and enriched.

As Co-Leads of AICRI, we are delighted to present this commissioned report '*Landscape Review and Economic Potential of the Oncology and Allied Digital Health Sector on the Island of Ireland*'. This report was supported via generous funding from InterTradeIreland under their

Synergy programme, with expert input provided by Salutem Insights. We wish to thank all of the contributors to this report, from industry leaders to members of state bodies and other stakeholders.

The report represents the first time that the industry ecosystem in the areas of oncology and allied digital health across the island of Ireland has been defined. The intelligence that has been generated highlights a vibrant industry sector, but also provides some key recommendations to maximise this potential even further, so as to better enable scaling of indigenous companies and to create a magnet to attract further Foreign Direct Investment to the sector. The report is extremely timely, emphasising how innovation in oncology and allied digital health can be a catalyst for the creation of new high value jobs and investment opportunities to enhance economic development and societal prosperity across the island.

The report also takes into consideration the discrete, natural strengths and complementary opportunities found in Ireland and Northern Ireland, providing ample supportive evidence for the emergence of an *All-Island Oncology Innovation Cluster*, which could aid consolidation and enhance growth of this key area. Some challenges in terms of R&D funding and critical infrastructure have been identified, which should be addressed in an integrated manner in order to accelerate innovation and drive societal and economic benefit, North and South.



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Abbreviations

ABPI	Association of the British Pharmaceutical Industry	DPFS	developmental pathway funding scheme	mRNA	messenger Ribonucleic Acid
AI	Artificial Intelligence	DTIF	Disruptive Technologies Innovation Fund	NCATS	National Center for Advancing Translational Sciences
AICRI	All-Island Cancer Research Institute	ECMC	Experimental Cancer Medicine Centre	NHS	National Health Service
AMBER	Advanced Materials and BioEngineering Research	EHR	Electronic Health Record	NI	Northern Ireland
APC	Alimentary Pharmabotic Centre	EI	Enterprise Ireland	NIB	Northern Ireland Biobank
ARC	Accelerating Research to Commercialisation	EIT	European Institute of Innovation and Technology	NIBRT	National Institute Bioprocessing Research and Training
ATMP	Advanced Therapeutic Medicinal Product	ELISA	Enzyme-Linked Immunosorbent Assay	NIH	National Institutes of Health
BERD	Business Expenditure on R&D	EPSRC	Engineering and Physical Sciences Research Council	NIPANC	Northern Ireland Pancreatic Cancer
BM	Bermuda	FMI	Future Medicines Institute	NK	Natural Killer
BRCD	Belfast Region City and Growth Deal	FR	France	NL	Netherlands
CAGR	Compound Annual Growth Rate	GMP	Good Manufacturing Practices	OSD	Oral Solid Dosage
CAR	Chimeric Antigen Receptor	GR	Glucocorticoid Receptor	OSFA	One-Size-Fits-All
Cas9	CRISPR associated protein 9	HEA	Higher Education Authority	PCR	Polymerase Chain Reaction
CDHT	Centre for Digital Healthcare Technology	HIHI	Health Innovation Hub Ireland	PET	Positron Emission Tomography
CDMO	Contract Development and Manufacturing Organization	HIRANI	Health Innovation Research Alliance Northern Ireland	POI	Precision Oncology Ireland
CDx	Companion Diagnostic	HQ	Headquarters	QUB	Queen's University Belfast
CeADAR	Centre for Applied Data Analytics Research	HRB	Health Research Board	R&D	Research and Development
CH	Switzerland	HSC	Health and Social Care	RCSI	Royal College of Surgeons in Ireland
CLIA	Clinical Laboratory Improvement Amendments	HSE	Health Service Executive	SE	Sweden
CN	China	Ibec	Irish Business and Employers Confederation	SFI	Science Foundation Ireland
CRF	Clinical Research Facility	ICS	Irish Cancer Society	SIC	Standard Industrial Classification
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats	IDA	Industrial Development Authority	SME	Small to Medium sized Enterprises
CRO	Companies Registration Office	IE	Ireland	SSPC	Synthesis and Solid State Pharmaceutical Centre
CRS	Cytokine Release Syndrome	IL	Israel	START	South Texas Accelerated Research Therapeutics
CRT	Centre for Research Training	IP	Intellectual property	TKI	Tyrosine Kinase Inhibitor
CRUK	Cancer Research UK	IPO	Initial Public Offering	TRL	Technology Readiness Levels
CT	Computer Tomography	iREACH	Institute of Research Excellence for Advanced Clinical Healthcare	UCD	University College Dublin
DE	Germany	IT	Italy	UK	United Kingdom
DETE	Department of Enterprise, Trade and Employment	JP	Japan	UG	University of Galway
DfE	Department for the Economy	KPI	Key Performance Indicator	US	United States
DFHERIS	Department of Further and Higher Education, Research Innovation and Science	KTP	Knowledge Transfer Programme	UU	Ulster University
		LHS	Life and Health Sciences	VC	Venture Capital
		MMUH	Mater Misericordiae University Hospital	WWW	World Wide Web
		MoAb	Monoclonal Antibody		
		MRC	Medical Research Council		

Table of Contents

Foreword	1
Abbreviations	2
List of Tables	4
List of Figures	4
Executive Summary	5
1. Introduction	9
2. Methodology	11
2.1. Identifying companies	11
2.2. Identifying economic potential	13
3. Results	15
3.1. Total companies	15
3.2. Wider ecosystem	15
3.3. Companies geolocation	16
3.4. Spin-out companies	18
3.5. Products and services offered	18
3.6. UK or US operations	19
3.7. Age of companies	20
4. Economic Potential	21
4.1. Current market size and potential value	21
4.2. Future economic potential	22
4.3. How does the island of Ireland compare to other life sciences clusters?	24
5. Capturing the full potential of oncology and allied digital health	27
5.1. R&D funding	27
5.2. Supportive infrastructure for early stage clinical trials	29
5.3. Collaboration	29
5.4. Investment in essential infrastructure	30
5.5. Shared Infrastructure	31
5.6. Case studies	31
6. Recommendations	41
6.1. All-Island Oncology Innovation Cluster	41
6.2. Supportive infrastructure	42
6.3. R&D funding	42
7. Conclusion	45
8. References	47
9. Acknowledgements	49
10. Appendix	51
10.1. Support ecosystem	51
10.2. Indigenous and multinationals with a presence on the island of Ireland	53

List of Tables

Table 1:	Company size	15
Table 2:	Entities supporting the ecosystem	15
Table 3:	University spin out companies	18
Table 4:	Products and services by segment	18
Table 5:	Distribution of precision and non-precision oncology companies on the island of Ireland	19
Table 6:	Global workforce of multinational companies with a presence on the island of Ireland	21
Table 7:	Global workforce of indigenous firms with a presence on the island of Ireland	21
Table 8:	Financial data from companies for 2022	22
Table 9:	CAGR rates for each market segment	23
Table 10:	Multinational firms' revenue for 2022, forecast to 2032	23
Table 11:	Indigenous firms' revenue for 2022, forecast to 2032	23
Table 12:	Illustrating key international comparative metrics for LHS clusters	25
Table 13:	Oncology support ecosystem of hospitals, academic and research centres, and charities on the island of Ireland	51
Table 14:	Oncology and digital health products/services available from companies on the island of Ireland	53

List of Figures

Figure 1:	Search Strategy	12
Figure 2:	Process flowchart – identifying economic potential	14
Figure 3:	Distributional spread of companies offering oncology products and services	16
Figure 4:	Cities map of company locations and associated ecosystem	16
Figure 5:	Average distance from academic centres (km)	18
Figure 6:	Global distribution of oncology and allied digital health company HQs with a presence on the island of Ireland	19
Figure 7:	Age of companies offering oncology and allied digital health products with a presence on the island of Ireland	20
Figure 8:	Companies with a presence on the island of Ireland posting capital and reserves or revenue	22



Executive Summary

The island of Ireland is a premier destination for life and health science (LHS) enterprises, boasting a distinctive blend of skilled professionals, cutting-edge research facilities, and robust collaborations between industry, academia, and healthcare practitioners. The oncology communities across academia and industry within Northern Ireland (NI) and Ireland (IE) are keen to enhance and upscale All-Island collaborative approaches, aspiring to elevate the entire island to global prominence in oncology and allied digital health endeavours. These are the fastest growing areas of the LHS sector, due to the increasing availability of multi-modal data, the development of genomics-driven cancer medicine and the growth in deployment of artificial intelligence (AI).

However, little data are available on the number of oncology and allied digital health companies operating on the island of Ireland. Data on the products/services these companies provide, numbers employed, the ecosystem they operate in, and the economic potential are also lacking. These data are necessary to benchmark performance, along with recommendations on how the LHS sector can be enhanced, to ensure that the full health and socioeconomic benefits of the growth in oncology and allied digital health research on the island are realised. As

such, Salutem Insights was commissioned by the All-Island Cancer Research Institute (AICRI; www.aicri.org), a cross-border virtual institute involving 10 universities on the island of Ireland and associated stakeholders, who have received funding under InterTradeIreland's Synergy Programme, to conduct a study to evaluate the current landscape and economic potential of oncology and allied digital health on the island of Ireland, examining this landscape through an all island and cross-border lens, to illuminate opportunities to increase trade and research and development (R&D) across the island.

We conducted a comprehensive search to identify all oncology and allied digital health companies, including both indigenous enterprises and multinational corporations, operating on the island of Ireland. Additionally, we examined the oncology and allied digital health support infrastructure, encompassing hospitals, academic and research centres, as well as charitable organisations and spin-outs, to ensure a thorough assessment of the sector. Economic potential was assessed by gathering details from company websites, annual reports, and financial statements, including products/services offered, overseas operations, revenue, profit, employee numbers, and distance from academic centres. Revenue, profit, R&D



spend, capital and reserves, and employee numbers were amalgamated and were benchmarked against other LHS clusters internationally to gauge their competitiveness.

A total of 172 oncology and allied digital health companies were identified, with 38 in NI and 134 in IE. The oncology and allied digital health sector is dominated by micro-companies in NI (39.5%) and larger companies in IE (51.5%). In terms of products and services offered by these companies, NI focuses more on diagnostics (25.6%) compared to IE (5.9%), while IE emphasises digital solutions (45.3%) more than NI (33.3%), IE also leads in the manufacture of drugs (29.4%) compared to NI (17.9%). In NI, nearly 40% of companies offered precision oncology products, whereas in IE, there was an almost equal division between precision and non-precision oncology companies.

Companies in NI and IE are supported by a wider ecosystem, comprising hospitals that treat oncology patients (n=10), cancer charities involved in significant research (n=11), academic (n=11) and research centres

(n=26). There are a larger number of research centres in IE (n=20) compared to NI (n=6). Most research centres in IE are supported by Science Foundation Ireland (SFI). Regarding university spinouts, a total of 17 and 21 companies were university spin-outs, representing 45% and 16% of all companies in NI and IE, respectively. Additionally, university spin-outs in NI demonstrate a higher propensity to scale up from micro and small enterprises to medium and large companies, compared to their counterparts in IE. The growth of indigenous oncology and allied digital health entities has surged over the past four decades.

Most companies in both NI and IE are concentrated around major cities of Belfast, Cork, Dublin, and Galway. Micro and small companies tend to cluster around academic centres, while large companies are often located near major transport arteries or in Dublin. Multinational corporations in the oncology and allied digital health sector employ over 4 million individuals globally, with NI and IE indigenous firms employing 215,612 people globally.

NI and IE were compared with international LHS clusters such as the Golden Triangle (London, Oxford, and Cambridge) and Biotech Bay (San Francisco). NI and IE individually demonstrate growth potential but are smaller in scale compared to these established clusters. Our analysis further indicates that the island of Ireland requires the creation of more companies and a higher R&D spend to compete with these clusters. The global oncology market is projected to reach \$690.4B by 2032. Companies in NI and IE are expected to contribute significantly to this growth, with revenue projections indicating substantial increases over the next decade.

Key stakeholders interviewed emphasise that growth in the oncology and allied digital health sector relies on critical factors such as R&D funding, supportive infrastructure for early-stage clinical trials, collaboration among academia, industry, and healthcare professionals, investment in essential infrastructure (bio-banks, access to electronic health records (EHRs), AI) and the creation of a centralised “one-stop shop” to streamline processes. Initiatives like Precision Oncology Ireland (POI) and the planned Future Medicines Institute (FMI), proposed by the NI Precision Biomarker and Therapeutic Consortium, exemplify the

potential of impactful industry-academia collaborations and cluster development. These elements, underscored by key stakeholders, are essential for unlocking the full potential of oncology and allied digital health in Ireland. Initiatives such as AICRI, which brings together 10 universities and associated teaching hospitals across the island of Ireland, along with other stakeholders, are also crucial enablers of the research and innovation landscape.

Based on the research findings presented in this Report and the insights gleaned, our key recommendations are:

- ▶ **Create an All-Island Oncology Innovation Cluster, to consolidate and promote the relative strengths in research, innovation and implementation in NI and IE, foster all-island and international collaboration, attract talent and investment including venture capital. This cluster should be resourced to stimulate investigation of cross-border opportunities with the aim of promoting cross-border trade and R&D and facilitating economic growth on the island of Ireland.**
- ▶ **Increase R&D funding on the island of Ireland to 3.5% in line with other Western countries and aligning with leading Life and Health Sciences (LHS) clusters around the world.**
- ▶ **Develop joint academic/industry/health infrastructure to facilitate better collaboration, knowledge transfer, skills and innovative diagnostics and therapeutics, e.g. the Future Medicines Institute (FMI).**
- ▶ **Address critical gaps in clinical infrastructure through the expansion of experimental Phase I oncology trials.**
- ▶ **Help solve critical gaps in digital health infrastructure, including the establishment of EHRs in IE and better access to patient data in NI.**
- ▶ **Explore the opportunities for robust all-island partnerships through the Shared Island Unit, PEACEPLUS and Northern Ireland City and Growth Deals.**

These recommendations align with the various industrial and R&D strategies in both NI and IE and build on existing clustering initiatives including the promotion of clustering by Health Innovation Research Alliance Northern Ireland (HIRANI) and University College Dublin's (UCD) AI Healthcare Hub. Additionally, there is alignment with PEACEPLUS's strategic programme of cross-border research in growth areas such as LHS and AI, healthcare service delivery and intervention trials, and enhancing cross-border collaboration in sectors such as healthcare through staff exchanges and training.

By adopting these recommendations, the island of Ireland has the potential to capitalise on the international growth in oncology and digital health and be a global leader in oncology research and its commercialisation.

Key Statistics

In total, 172 oncology and allied digital health companies were identified on the island of Ireland, NI (n = 38) and IE (n = 134).

NI has a higher proportion of micro-companies (39.5%), while IE is dominated by larger companies (51.5%).

The focus in IE is on digital solutions (45.3%) and drug manufacturing (29.4%), while NI focuses on diagnostics (25.6%).

In NI, 39.5% of companies offer precision oncology products or services, while in IE, the corresponding figure is 49.3%.

A total of 45% and 16% of all identified companies in NI and IE respectively were university spin-outs.

Regarding the wider ecosystem, in NI, there are 2 academic institutions (13.3%), 6 research centres (40.0%), 2 oncology hospitals (13.3%), and 5 major cancer research charities (33.3%). In IE, there are 9 academic institutions (20.9%), 20 research centres (46.5%), 8 hospitals (18.6%), and 6 major cancer research charities (14.0%).

There is a notable multinational presence, with 43 US and 11 UK companies operating in Ireland. Other countries have less than 5 companies operating in Ireland.

Multinational corporations in the oncology and allied digital health sectors, operating on the island of Ireland, employ a total of 4,320,712 individuals globally. In contrast, indigenous companies in NI and IE within this sector have a combined global workforce of 215,612.

The combined revenue of all companies providing oncology and allied digital health products and services on the island of Ireland approached €2.4 trillion in 2022. Projections indicate a substantial increase to over €10.7 trillion by 2032.



1 Introduction

The island of Ireland is a global centre for life and health sciences (LHS). The sector employs 19,500 people in Northern Ireland (NI) and over 102,000 people across Ireland (IE) ^(1, 2). The biggest growth areas in the LHS sector include oncology and allied digital health ^(3, 4, 5, 6, 7, 8). The growth in the oncology sector is driven mainly by precision oncology, which tailors treatment to individual patients. Precision oncology is rapidly advancing due to the increasing availability of genomic data, the development of genomics-driven cancer medicine, and through growth in artificial intelligence (AI) capabilities ⁽⁹⁾. Precision oncology has already significantly improved cancer management and has the potential to revolutionise cancer care on the island of Ireland, drive innovation and produce economic benefit ^(9, 10). Recent research has highlighted how precision oncology can deliver value to financially-challenged health systems ⁽⁶⁾.

The NI and IE LHS landscape comprises both multinationals and an indigenous LHS community. The success of the LHS sector is driven by a combination of factors: a skilled and well-educated workforce; a favourable tax environment (particularly for IE); supportive industrial strategies including research and development (R&D) funding, infrastructure investment, and an ecosystem that supports innovation ^(11, 12, 13, 14, 15). An attractive ecosystem comprises

research institutions, universities, incubators, accelerators, spin-outs, and other organisations that collaborate and foster entrepreneurship and innovation ^(14, 15). Innovation in the context of oncology and allied digital health refers to the continuous advancement and integration of groundbreaking technologies, methodologies, and approaches aimed at revolutionising cancer care and its delivery. The level of innovation in a country is particularly relevant when a company is looking for new opportunities such as collaboration, scientific discovery, and venture capital (VC) funding ⁽¹⁶⁾.

Academic and industry oncology stakeholders within NI and IE are keen to collaborate further and with even greater alignment aspiring to elevate the entire island to global prominence in oncology and allied digital health. However, little intelligence is available on the number of oncology and allied digital companies operating on the island of Ireland. Data on the products/services these companies provide, the relative split between traditional “one-size-fits-all” oncology and precision oncology approaches, numbers employed, the ecosystem they operate in, and their economic potential are also lacking. These data, along with recommendations on how the LHS sector can be enhanced, are necessary to ensure that the island of Ireland

is appropriately positioned to realise the full benefit of the potential growth in oncology and allied digital health. In this regard, SaluTem Insights was commissioned by the All-Island Cancer Research Institute (AICRI), a cross-border virtual institute involving 10 universities on the island of Ireland and associated stakeholders, who have received funding under InterTradeIreland's Synergy Programme to conduct a study to evaluate the current landscape and economic potential of oncology and allied digital health on the island of Ireland. The study aimed to provide evidence-based recommendations for maximising the potential of these sectors within the region.

This report is laid out as follows:

- ▶ **Section 2** describes the methodology employed to collect data for the landscape review.
- ▶ **Section 3** presents the results of the landscape review.
- ▶ **Section 4** estimates the potential economic impact of a well-functioning oncology and digital health ecosystem on the island of Ireland.
- ▶ **Section 5** contains interviews with key stakeholders on how the oncology and allied digital health sectors can be elevated to ensure that the projected growth in these sectors occur on the island of Ireland.
- ▶ **Section 6** includes recommendations on how best to maximise the impact and benefit of an oncology and allied digital health nexus based on the evidence provided.
- ▶ **Section 7** presents concluding remarks.





2 Methodology

2.1 Identifying companies

The objective of the search strategy was to identify all oncology and allied digital health companies on the island of Ireland. This landscape analysis encompassed any device, diagnostic tool, digital solution, discovery platform (technological or service-oriented tools utilised in drug discovery and production), or drug, employed in the diagnosis, treatment and management of cancer.

Northern Ireland

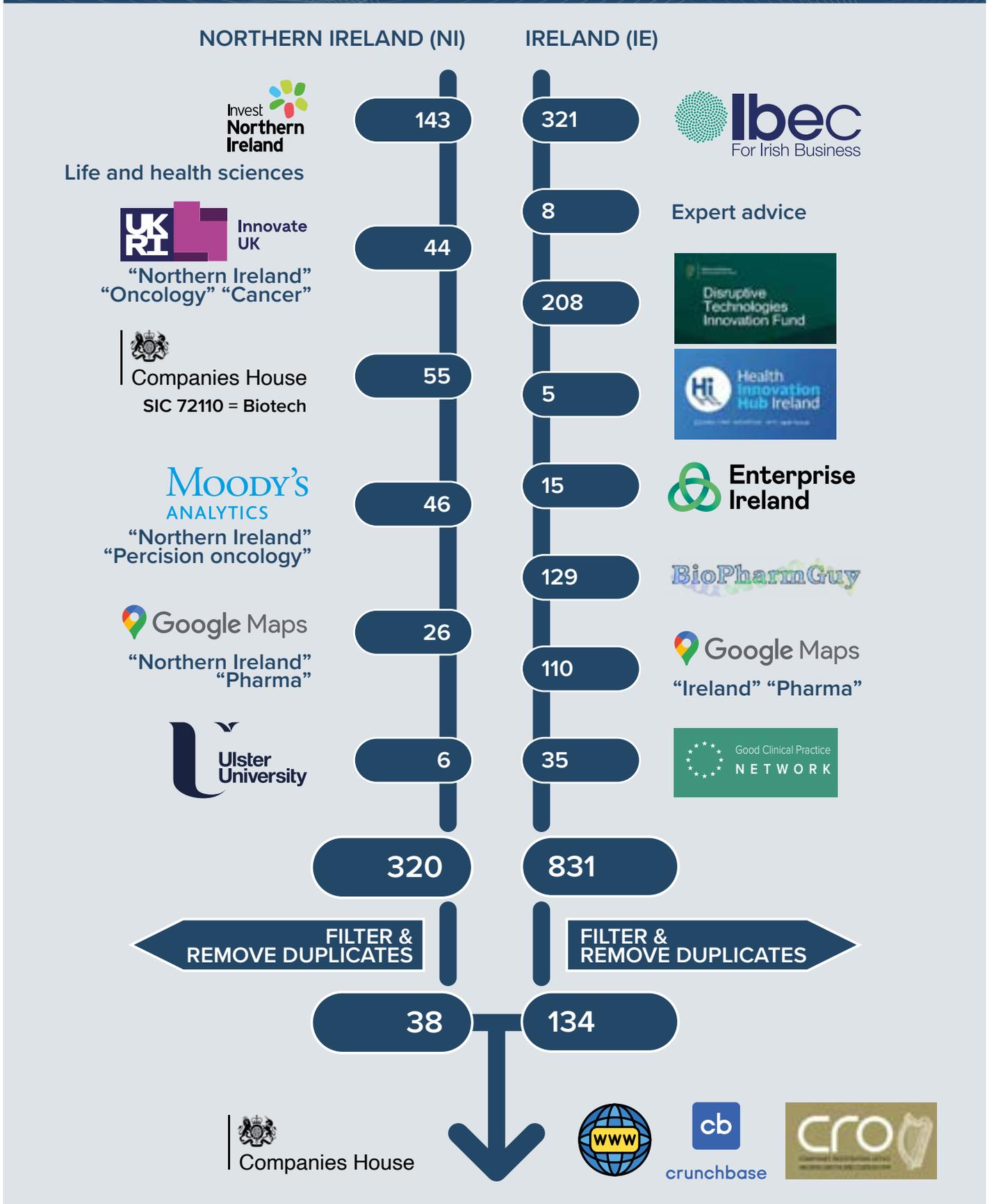
Online directories in NI were searched, including Invest NI (Life and Health Sciences)⁽¹⁷⁾ and Companies House (Biotech, standard industrial classification = 72110)⁽¹⁸⁾. On request, the Knowledge Transfer Programme (KTP) provided a directory of funded projects from Innovate UK⁽¹⁹⁾, which was searched with the search strings “Northern Ireland”, “Oncology”, and “Cancer”. Invest NI conducted a Moody’s Analytics search on our behalf using the search strings “Northern Ireland” and “Precision oncology”. Ulster University (UU) provided us with a list of spin out companies, and to ensure a comprehensive database as possible a broad search was conducted using Google Maps using the search strings “Northern Ireland” and “Pharma”, see Figure 1.

Ireland

For IE, we first contacted the Department of Enterprise, Trade and Employment (DETE) who provided us with the Disruptive Technologies Innovation Fund (DTIF) directory⁽²⁰⁾ and a publication by the Irish Business and Employers Confederation (Ibec)—“Where Digital Health Thrives”⁽²¹⁾. Irish pharmaceutical directories such as the BioPharmGuy⁽²²⁾ and Good Clinical Practice Network were also searched⁽²³⁾. In addition, Enterprise Ireland (EI) and the Health Innovation Hub Ireland (HIHI) emailed us lists of relevant companies included in their directories. All these directories were supplemented by a Google Maps search using the strings “Ireland” and “Pharma”, and expert advice from our academic partners highlighted companies that might have been missed, see Figure 1.

All these directories were compiled into two databases (NI and IE) and given an identification reference. The results were filtered to match oncology and allied digital health companies and any duplicates were removed. Additionally, the oncology support ecosystem of hospitals that treat oncology patients (n=10), cancer charities supporting research (n=11), academic institutions (n=11) and research centres (n=26) in both NI and IE were identified. University spin-outs were identified by searching company websites for their origin and cross-checking the list of spin-outs from the universities.

FIGURE 1: Search Strategy



CRO: Companies Registration Office; Ibec: Irish Business and Employers Confederation; SIC: Standard Industrial Classification; UKRI: UK Research and Innovation; WWW: World-Wide Web

2.2 Identifying economic potential

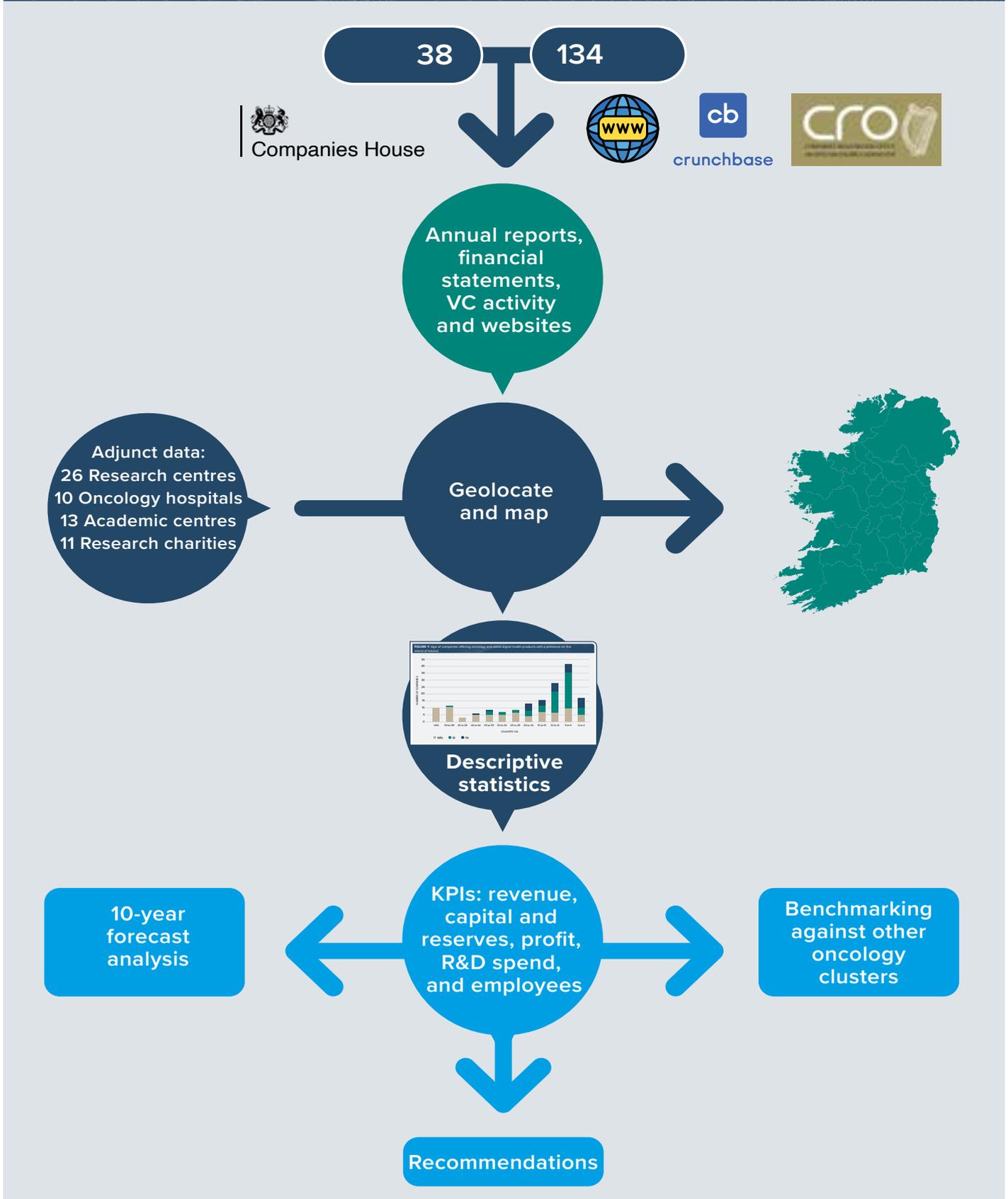
Following the process employed in Figure 2, once companies and bodies in the oncology ecosystem had been identified, locations were derived from each organisation website and these fields entered into Geoapify, an online geocoding tool, to determine each location's latitude and longitude on a map of the island of Ireland ⁽²⁴⁾, which was crossed checked with Google Maps latitude/longitude tool. Further details on each company were gathered from their websites, annual returns, financial statements, Google Maps, and business intelligence and market research websites. The data extracted were as follows:

1. Products/services offered
2. Overseas operations (location)
3. Incorporation date
4. Capital and reserves or revenue, profit, and R&D spend
5. Number of employees
6. Company size and age
7. Distance from academic centre
8. Spin-out company
9. Precision oncology or one size fits all oncology company

Annual reports and financial statements were analysed for metrics such as capital and reserves, total revenue, profit, and R&D spend. When annual reports and financial statements were not available, Crunchbase was queried for estimates of revenue or VC funding as a proxy for capital and reserves.

Employee numbers were also noted but, as with monetary values, these metrics did not distinguish between global and indigenous origin. Revenue, profit, R&D spend, capital and reserves, and employee numbers were amalgamated for 2022 to establish the market size for companies offering oncology and allied digital health products and services with a presence on the island of Ireland. We utilized these metrics to predict revenue growth for oncology and allied digital health companies from 2022 up to 2032, using specific compound annual growth rates (CAGR) for each product and service segment; device, diagnostic, digital, discovery, and drugs. Finally, IE and NI were benchmarked against other LHS clusters to assess their current standing compared to international competitors.

FIGURE 2: Process flowchart - identifying economic potential



Note: There is a disconnect between the number of academic centres geolocated and the number analysed in the ecosystem as UU has 3 locations. CRO: Companies Registration Office; IE: Ireland; KPIs: Key performance indicators; LHS: Life and Health Sciences; NI: Northern Ireland; UU: Ulster University; VC: Venture Capital; WWW: World-Wide Web



3 Results

3.1 Total companies

Overall, 38 companies in NI and 134 companies in IE were identified, a total of 172 companies. The 38 companies revealed by the landscape search in NI comprised 15 micro (less than 10 employees), 9 small (10 to 49 employees), 7 medium (50 to 249 employees), and 7 large companies (more than 250 employees). The 134 companies in IE comprised 25 micro, 32 small, 8 medium and 69 large companies, see Table 1. The majority (39.5%) of the 38 companies in NI fall into the micro category, followed by small (23.7%), and an even split between medium and large companies (18.4%). In IE, most companies (51.5%) belong to the large category, followed by small (23.9%), micro (18.7%), and, finally, medium categories (6%). Overall, our analysis indicates that the oncology and allied digital health sector on the island of Ireland is dominated by larger companies in IE and micro companies in NI.

Table 1: Company size

Firm size	NI, N(%)	IE, N(%)
Micro	15 (39.5)	25 (18.7)
Small	9 (23.7)	32 (23.9)
Medium	7 (18.4)	8 (6.0)
Large	7 (18.4)	69 (51.5)
Total	38 (100.0)	134 (100.0)

IE: Ireland; N: Number; NI: Northern Ireland

3.2 Wider ecosystem

Table 2 provides a breakdown of the number of non-company oncology entities including hospitals (n=10), cancer charities involved in significant cancer research (n=11), academic institutions (n=11) and research centres (n=26). The research charities and centres identified are those with a track record of supporting research discovery in oncology or allied digital health on the island of Ireland. In NI, there are 2 academic centres (13.3%), 6 research centres (40.0%), 2 oncology hospitals (13.3%), and 5 research charities (33.3%). Comparatively, in the IE, there are 9 academic centres (20.9%), 20 research centres (46.5%), 8 oncology hospitals (18.6%), and 6 research charities (14.0%). Notably, there is a greater concentration of research centres in IE compared to NI, even when per capita rate is accounted for. Most research centres in IE are supported by Science Foundation Ireland (SFI). A more detailed breakdown of the wider support system is provided in Table 13 of the Appendix.

Table 2: Entities supporting the ecosystem

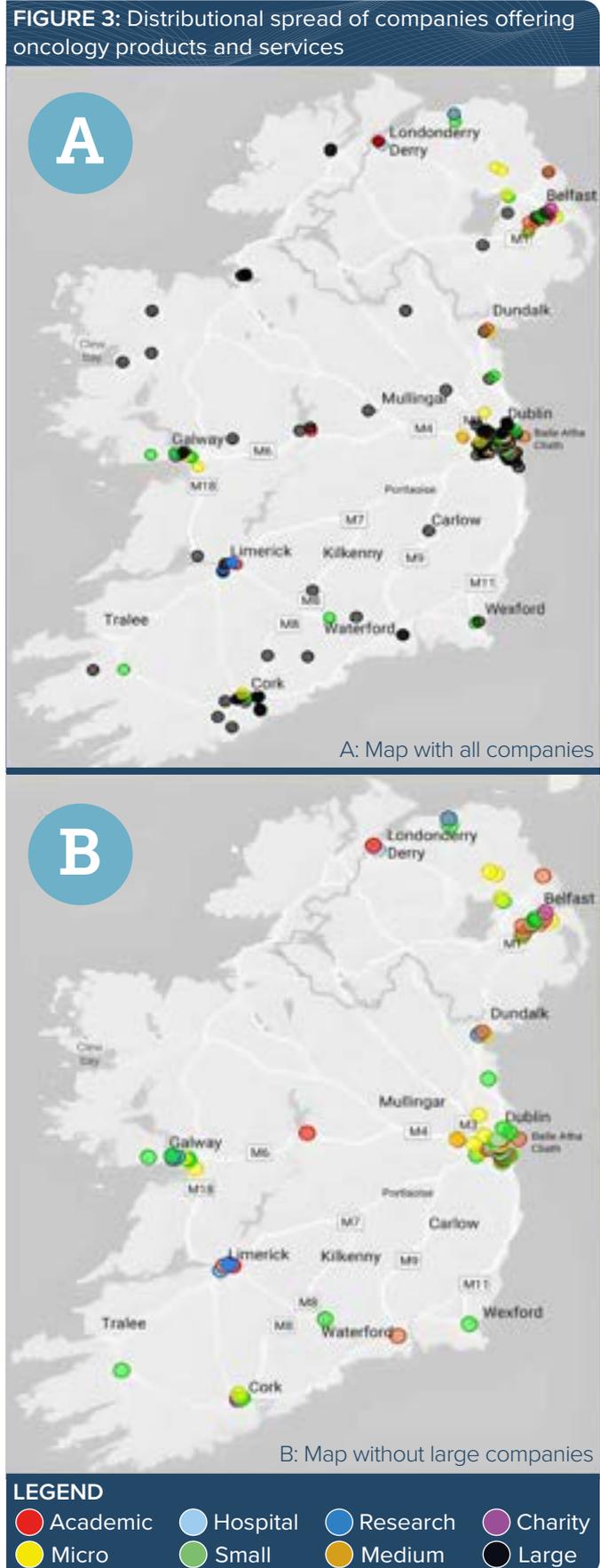
Support	NI, N(%)	IE, N(%)	NI&IE, N(%)
Academic	2 (13.3)	9 (20.9)	11 (19.0)
Research centres	6 (40.0)	20 (46.5)	26 (44.8)
Hospital	2 (13.3)	8 (18.6)	10 (17.2)
Charities	5 (33.3)	6 (14.0)	11 (19.0)
Total	15 (100.0)	43 (100.0)	58 (100.0)

IE: Ireland; N: Number; NI: Northern Ireland

3.3 Companies geolocation

Employing Power BI (Microsoft Corp), each identified company (some large companies had multiple locations, e.g., AbbVie, Pfizer), oncology hospital, research centre, academic centre, and research charity were geolocated onto a map of the island of Ireland. Every organisation type was colour coded and, where relevant, the colour codes were broken down by company size. The results of this analysis show that there is a concentration of companies around the major cities of Belfast, Cork, Dublin, and Galway. Companies that are located outside the cities tended to be situated alongside the major transport arteries of the island of Ireland, see Figure 3, panel A. Additionally, when large corporations were removed from the map to project a clearer view of indigenous enterprises, see Figure 3 panel B, most companies were observed to be clustered around the main cities. As the locations in most cities could not be discerned at this scale, we zoomed in on Belfast, Cork, Dublin, and Galway to assess the spread of organisations at a more granular level, see Figure 4.

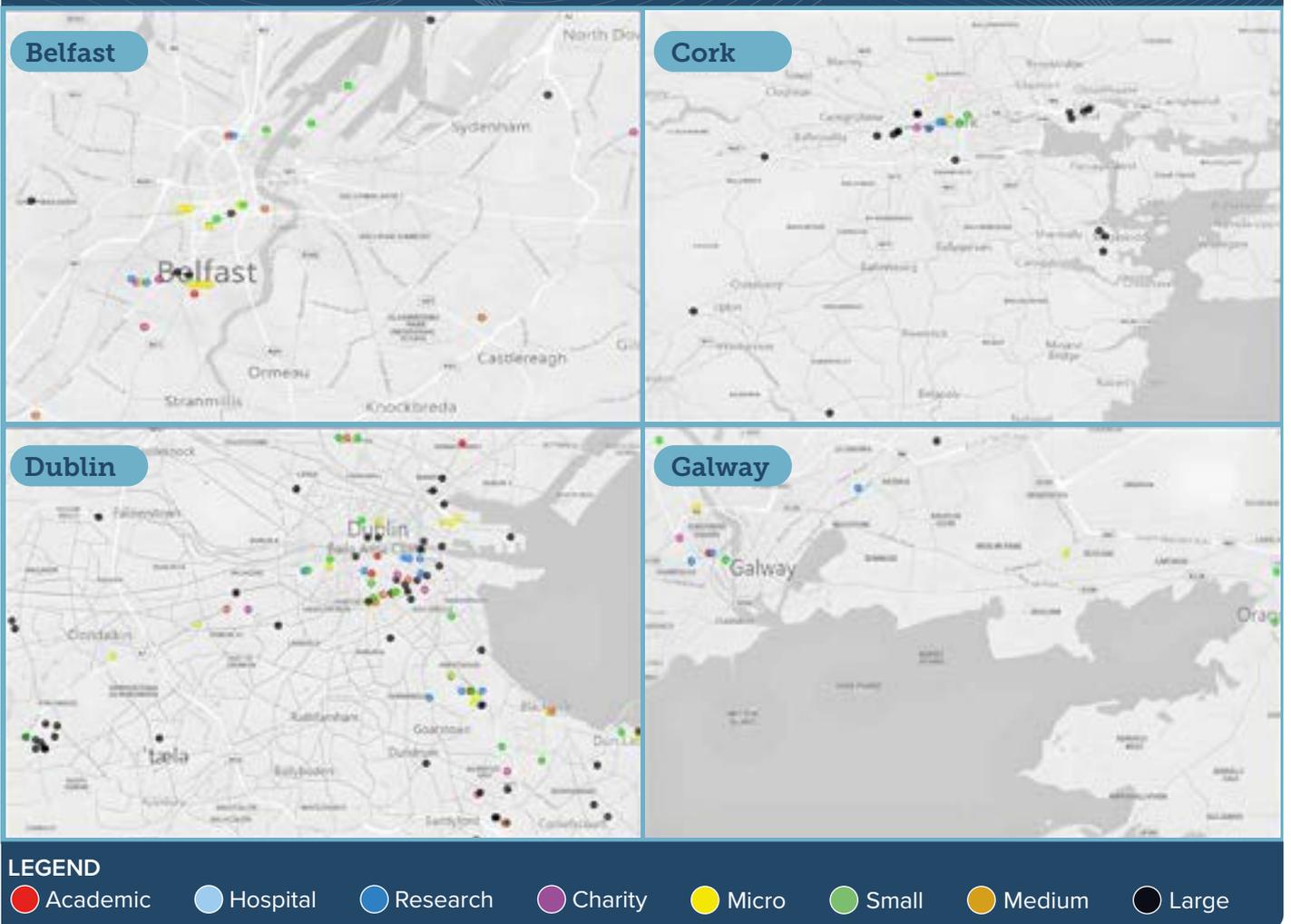
On comparing the map of the island of Ireland with the maps of the cities, there was seen to be a concentration of micro and small companies in the cities. Large companies tended to concentrate in the regions close to motorways or in Dublin where their headquarters are located, although Cork was an exception to this rule. Micro and small companies tended to cluster around academic centres. Additionally, micro companies which were dominated by university spin-outs, were located at an average distance of 3.7km for NI and 5.9km for IE from academic centres, see Figure 5. Small companies were the next most distant from academic centres at an average distance of 12.4km for NI and 16.5km for IE. Medium sized companies tended to be closer to academic centres but the dataset for this category was very small. Finally, large companies in IE tended to be relatively close to academic centres, this is most likely due to many large companies headquartered in Dublin, with several major universities nearby.



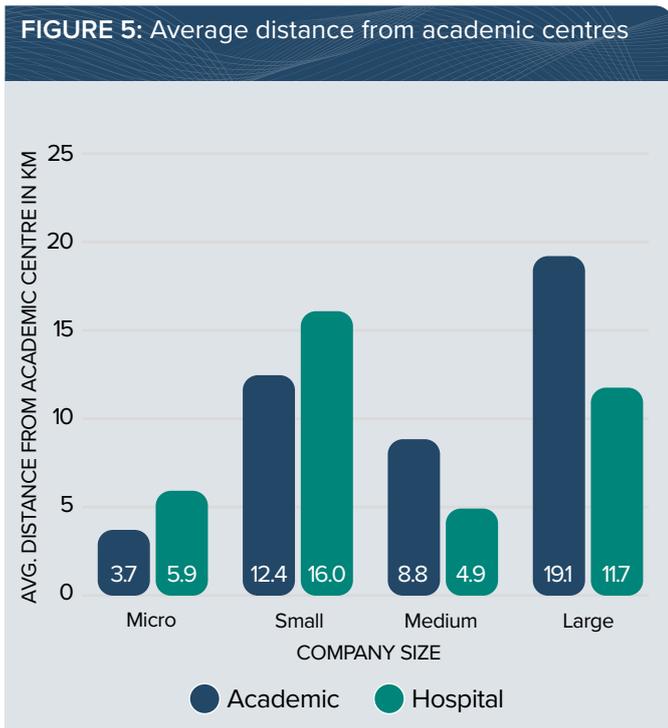
Note: Academic institution denotes university while research centre is usually associated with university but in this case has a major focus on oncology and/or allied digital health



FIGURE 4: Cities map of company locations and associated ecosystem



Note: Academic institutions denotes university while research centre is usually associated with university but in this case has a major focus on oncology or allied digital health



Avg.: Average; IE: Ireland; km: kilometre; NI: Northern Ireland

3.4 Spin-out companies

A total of 17 and 21 companies were identified as university spin-outs representing 45% (NI) and 16% (IE) of all companies identified. Table 3 highlights a notable trend: spin-outs from NI demonstrated a higher propensity to scale up from micro and small enterprises to medium and large companies, compared to their counterparts in IE. University spin-out companies in NI which made it to the medium class are **Cirdan** and **Fusion Antibodies**, while those companies which attained large class status were **Andor Technology**, **Almac**, and **Kainos**. The data revealed an absence of medium or large companies in IE stemming from university spin-outs.

Table 3: University spin outs companies

Firm size	NI, N(%)	IE, N(%)
Micro	10 (58.8)	8 (38.1)
Small	2 (11.8)	13 (61.9)
Medium	2 (11.8)	0 (0)
Large	3 (17.7)	0 (0)
Total	17 (100)	21 (100)

IE: Ireland; N: Number; NI: Northern Ireland

3.5 Products and services offered

Table 4 offers valuable insights into the composition of products and services supplied by these companies in both NI and IE. In NI, there was a demonstrated lower emphasis on digital solutions, with 33.3% of companies in this category compared to IE's higher percentage of 45.3%. NI appeared to have a stronger focus on diagnostics, with 25.6% of companies compared to only 5.9% in IE. Additionally, IE showed a notable dominance in drug manufacturing, with 29.4% of companies, whereas in NI drug manufacturing constituted 17.9% of entities.

Table 4: Products and services by segment

Segment	NI, N(%)	IE, N(%)
Device	2 (5.1)	18 (10.6)
Diagnostic	10 (25.6)	10 (5.9)
Digital	13 (33.3)	77 (45.3)
Discovery	7 (17.9)	15 (8.8)
Drug	7 (17.9)	50 (29.4)
Total	39 (100.0)	170 (100.0)

* The total count of individual oncology and allied digital health companies may exceed 172 due to potential double counting. This occurs when companies offer multiple products or services within the sector, such as Roche, which is classified as a drug company but also provides digital and diagnostic products. In our sample, 39 companies offer two or more products or services, contributing to potential overlap in the total count.

IE: Ireland; N: Number; NI: Northern Ireland

Table 5 illustrates the distribution of companies in NI and IE based on their engagement in precision oncology. In NI, precision and non-precision oncology (or what we term as One-Size Fits-All (OSFA) oncology) companies represented 39.5% and 60.5% of the total, respectively. Conversely, in IE, there was a more balanced distribution, with 49.3% of companies offering precision oncology products or services, and 50.7% in the OSFA category. This disparity between NI and IE was attributed to the substantial presence of multinational pharmaceutical firms in IE, the majority of which offered precision oncology products.

Table 5: Distribution of precision and non-precision oncology companies on the island of Ireland

	NI, N(%)	IE, N(%)
Precision oncology	15 (39.5)	66 (49.3)
OSFA oncology	23 (60.5)	68 (50.7)
Total	38 (100.0)	134 (100.0)

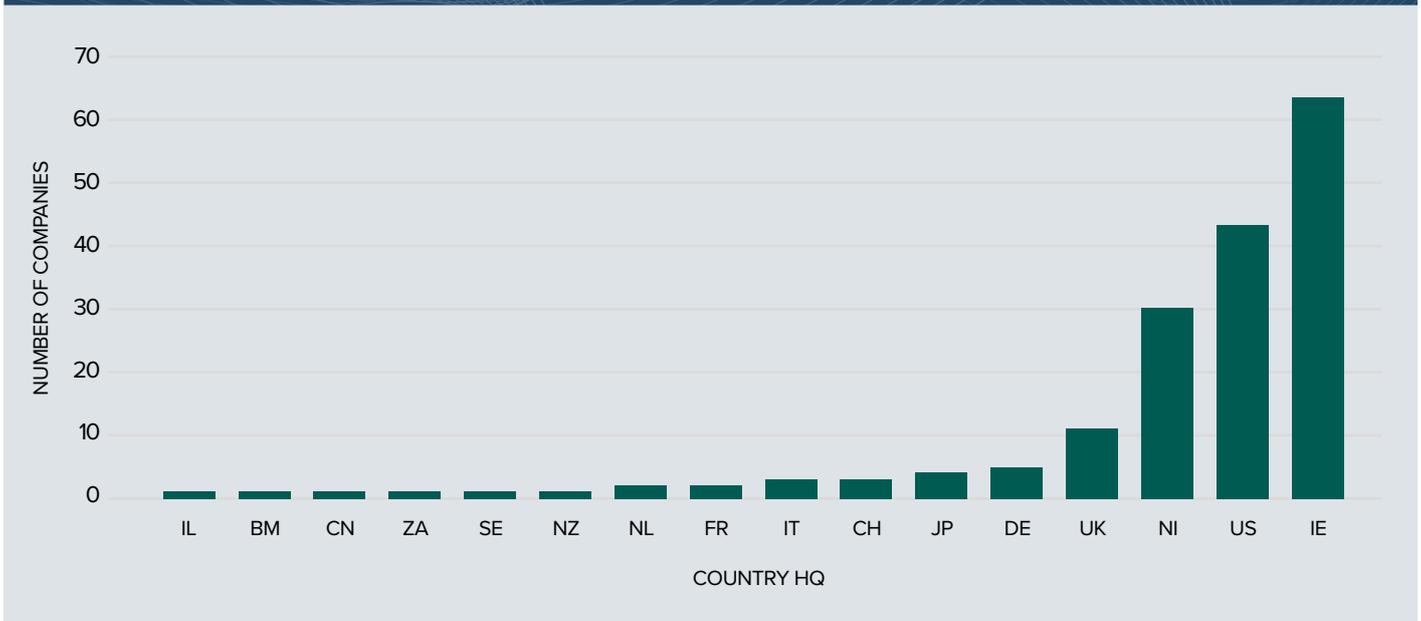
IE: Ireland; N: Number; NI: Northern Ireland; OSFA: One-Size-Fits-All

For a comprehensive overview of the oncology and allied digital health products and services offered by these companies, please refer to Table 14 in the Appendix.

3.6 UK or US operations

Most oncology and allied digital health companies on the island were indigenous NI or IE companies, numbering 30 and 63 respectively, as shown in Figure 6. However, there are 43 US oncology and digital health companies operating in Ireland, while there are 11 UK companies, underscoring the significant multinational presence from these nations. Other countries, specified in Figure 6, maintained five or fewer companies with operations on the island of Ireland.

FIGURE 6: Global distribution of oncology and allied digital health company HQs with a presence on the island of Ireland



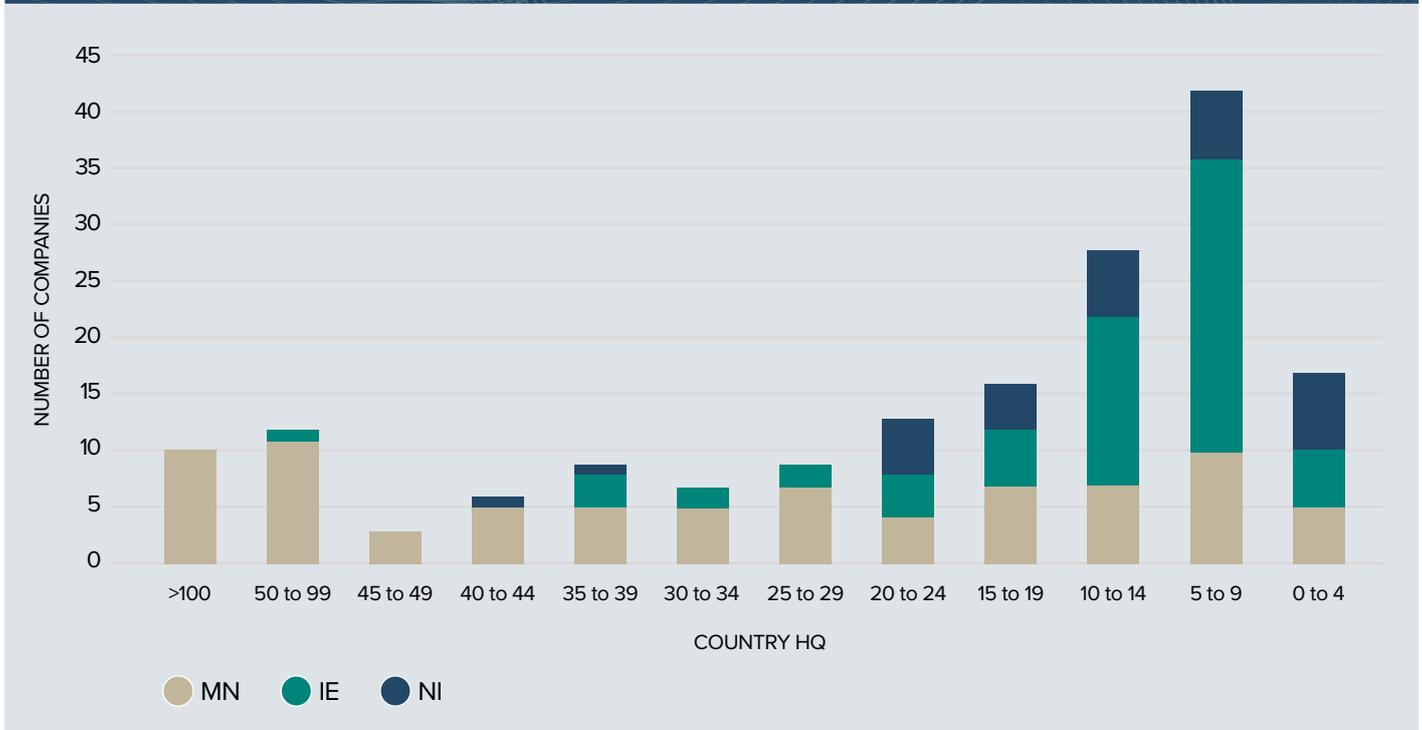
BM: Bermuda; CH: Switzerland; CN: China; DE: Germany; FR: France; HQ: Headquarters; IE: Ireland; IL: Israel; IT: Italy; JP: Japan; NI: Northern Ireland; NZ: New Zealand; SE: Sweden; UK: United Kingdom; US: United States; ZA: South Africa

3.7 Age of companies

Few indigenous companies in the industry have a history of over 50 years, with Medtronic being a notable exception. Despite its founding in 1949, **Medtronic's** headquarters in IE stemmed from its acquisition of an Irish company in 2015, while its operational and executive headquarters remained in Minneapolis, US. **Randox**, on the other hand, established 42 years ago and based in NI, has been a

significant regional player. It is worth noting that the growth of indigenous oncology and allied digital health entities has surged primarily in the last four decades. This momentum can be attributed to the rise of data collection and personal computers in the 1980s, followed by the genomics revolution in the 1990s, see Figure 7. There has been steady growth of companies locating on the island of Ireland since the 1990s, although multinational and indigenous IE company growth has slowed in the last 4 years.

FIGURE 7: Age of companies offering oncology and allied digital health products with a presence on the island of Ireland



IE: Ireland; MN: Multinational; NI: Northern Ireland



4 Economic Potential

4.1 Current market size and potential value

Multinational corporations with a presence on the island of Ireland in the oncology and allied digital health sectors collectively employ 4,320,712 individuals worldwide, while NI and IE firms within this domain have a global workforce totalling 215,612, see Table 6 and Table 7. These employee numbers do not match the 121,500 employees in the LHS sectors in both NI and IE highlighted in the introduction, because the indigenous companies analysed have a global workforce and it was not possible in this project to differentiate between global and local employees. This could be explored more fully in a future research project.

Table 6: Global workforce of multinational companies with a presence on the island of Ireland

Firm size	Number of employees		
	NI	IE	Total
Micro	6	8	14
Small	0	123	123
Medium	229	251	480
Large	3,956	4,316,139	4,320,095
Total	4,191	4,316,521	4,320,712

IE: Ireland; Northern Ireland

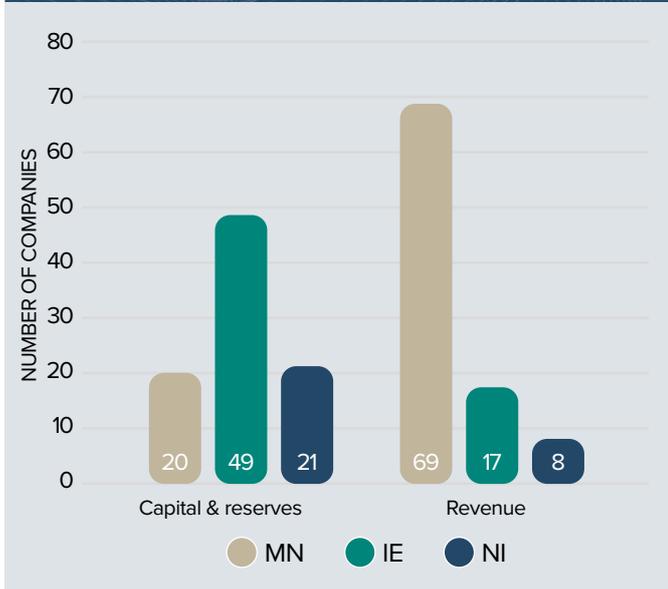
Table 7: Global workforce of indigenous firms with a presence on the island of Ireland

Firm size	Number of employees		
	NI	IE	Total
Micro	57	122	179
Small	257	590	847
Medium	376	770	1,146
Large	8,943	204,497	213,440
Total	9,633	205,979	215,612

IE: Ireland; Northern Ireland

Out of the 172 companies examined, 164 provided access to annual reports, financial statements, or were analysable for revenue and funding through third-party market intelligence platforms, such as Crunchbase. The remaining eight companies were either newly launched, recently acquired, or did not disclose their financial information. Sixty-nine of the 79 multinationals posted their revenue, see Figure 8 while 20 of the 79 posted their capital and reserves. Indigenous companies in both NI and IE were more inclined to report capital and reserves rather than revenue, likely attributed to the prevalence of micro-enterprises in NI and IE, many of which are still in their startup phase and may not have generated significant revenue in the timeframe of this report.

FIGURE 8: Companies with a presence on the island of Ireland posting capital and reserves or revenue



IE: Ireland; MN: Multinational; NI: Northern Ireland

Among the 164 companies where financial data were available, 90 solely reported capital and reserves, 94 reported revenue, 87 reported profits, and 70 reported R&D spend. The “Total” row in Table 8 aggregates the financial for both indigenous and multinational companies representing the cumulative average figures for capital and reserves, revenue, profit, and R&D spend. In this row, the total capital and reserves amount to almost €9.26 billion (B), total revenue stands just over €2.37 trillion (T), total profit amounts to over €768B and total R&D spend is just over €307B.

Table 8: Financial data from companies for 2022

	Capital & reserves (millions)	Revenue (millions)	Profit (millions)	R&D spend (millions)
Number of firms	90	94	87	70
Indigenous to NI	€ 109	€ 851	€ 286	€ 9
Indigenous to IE	€ 300	€ 41,684	€ 7,870	€ 2,784
NI based multinational	€ 15	€ 12,481	€ 5,828	€ 686
IE based multinational	€ 8,833	€ 2,316,899	€ 754,469	€ 303,767
Total	€ 9,257	€ 2,371,915	€ 768,453	€ 307,246

IE: Ireland; NI: Northern Ireland; R&D: research and development

4.2 Future economic potential

In 2022, the global oncology market had surged to \$280B in value and is projected to maintain a robust compound annual growth rate (CAGR) of 9.7%. This growth is primarily fuelled by the escalating global cancer burden (25). By 2032, the market is anticipated to soar to a value of \$690.4B (25). Furthermore, the diagnostics and digital markets are experiencing unprecedented growth, with CAGRs of over 19%, with key drivers including plummeting genomics sequencing costs and the pharmaceutical industry’s rapid adoption of cloud-based solutions and AI-driven technologies (26, 27).

There exists a notable disparity between the size of the 2022 global oncology market, valued at \$280B (€227B), and the market served by companies with a presence on the island of Ireland, which is over €2.37T, an over tenfold difference. This difference primarily stems from the significant presence of multinational allied digital health companies and pharmaceutical companies. The top five companies in our database, specialising in device and digital healthcare, collectively generate a global revenue of €1.4T. Meanwhile, the top five pharmaceutical companies in our sample have a combined global revenue of over €327B. Although these allied digital health companies have oncology portfolios among their offerings, it represents only a fraction of their overall business scope, while pharmaceutical companies which have oncology activity also cover therapeutic areas other than cancer.

Acknowledging the diverse segments encompassed by the sector, including devices, diagnostics, digital healthcare, discovery, and drug manufacturing, each with distinct growth rates, we have opted for a nuanced strategy in applying the CAGR to estimate the future global economic potential and revenue of oncology and allied digital health companies with a presence in Ireland. Specifically, rather than employing a uniform 9.7% CAGR, we adopted a more granular approach, assigning a specific CAGR to each market segment. This tailored approach allows for a more precise reflection of the unique growth trajectories inherent to individual segments within the overall sector, see Table 9.

Table 9: CAGR rates for each market segment

Market segment	CAGR 2022 to 2032	Source
Devices	5.90%	IMed Consultancy
Genomics (Diagnostics)	19.40%	Skyquest
Artificial Intelligence (Digital)	19.10%	Precedence Research
LHS (Discovery)	11.75%	Market Reports World
Biopharmaceutical (Drugs)	9.07%	Global Market Insights

CAGR: Compound Annual Growth Rate;
LHS: Life and Health Sciences

Source: IMed (2023) ⁽²⁸⁾, Skyquest (2023) ⁽²⁶⁾, Precedence (2023) ⁽²⁹⁾, Market Reports (2023) ⁽³⁰⁾, and Global Market Insights (2023) ⁽²⁵⁾

Table 10 illustrates financial projections for multinational companies in billions of euros across various market segments, comparing the base-case figures for 2022 with a ten-year forecast for 2032. In 2022, the revenue of all multinationals operating on the island of Ireland was just over €2.3T and is expected to increase to almost €10.6T in 2032.

Table 10: Multinational firms' revenue for 2022, forecast to 2032

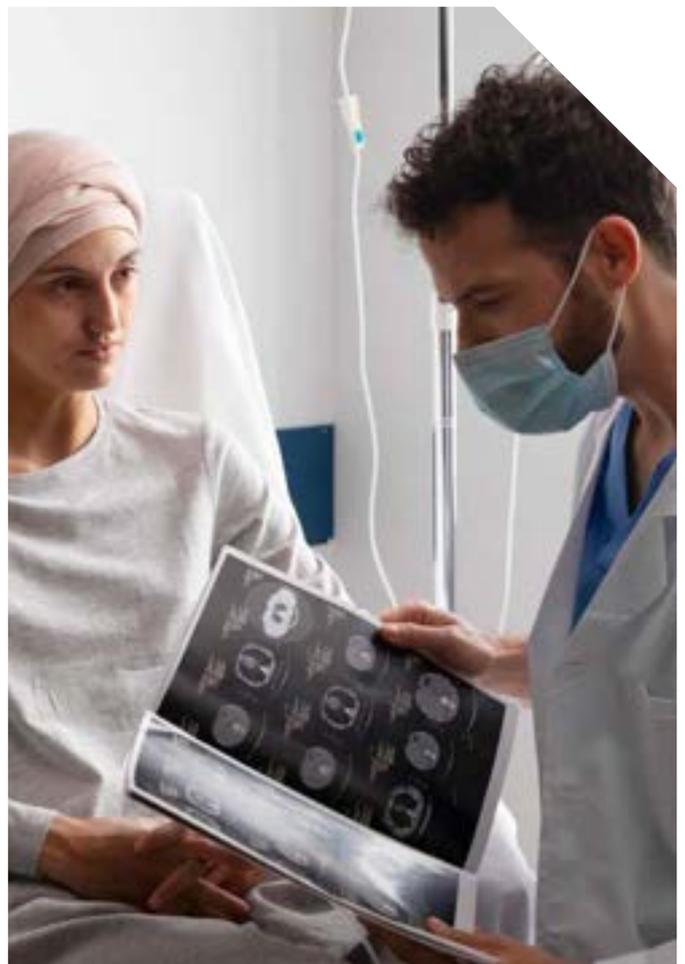
	Multinational firms, € billions	
	Basecase (2022)	Forecast (2032)
Device	€ 83	€ 147
Diagnostic	€ 66	€ 389
Digital	€ 1,409	€ 8,093
Discovery	€ 7	€ 22
Drug	€ 764	€ 1,928
Total	€ 2,329	€ 10,579

In 2022, revenue exclusively from NI and IE firms amounted to just under €42.54B. Projections indicate an increase to just over €133.86B in 2032, a rise of 215% see Table 11.

Table 11: Indigenous firms' revenue for 2022, forecast to 2032

	Indigenous firms, € millions	
	Basecase (2022)	Forecast (2032)
Device	€ 25,677	€ 45,552
Diagnostic	€ 7,455	€ 43,904
Digital	€ 6,421	€ 36,875
Discovery	€ 6	€ 19
Drug	€ 2,975	€ 7,509
Total	€ 42,535	€ 133,859

The global cumulative revenue of all companies operating on the island of Ireland which offer oncology and allied digital health products and services, reached just under €2.4T in 2022. It is projected to soar to over €10.7T by 2032, a rise of 346%. It would be informative to pinpoint oncology and allied digital health products and services specifically at a NI and IE level and if this financial data becomes available it will inform a line of future work.



4.3 How does the island of Ireland compare to other life sciences clusters?

Geographical agglomeration is crucial for long-term competitiveness in specialised industries, making clustering a common approach for regional development policies. Proximity among firms in clusters stimulates productivity, innovation, and the formation of new businesses, while facilitating access to specialized talent, technology innovations, and the exchange of ideas, fostering cooperation and mutual benefits within competing fields ⁽³¹⁾. A crucial element of technology-based clusters is the integral role of universities, serving as a source of experts, knowledge, and collaborative opportunities with industries, thereby contributing significantly to technological development, innovation and value ⁽³¹⁾. Several LHS cluster examples are described here:

1. The Golden Triangle, encompassing Oxford, Cambridge, and London in the southeast of England, is a renowned science, technology, and innovation cluster. In 2022, the LHS sector within this region experienced substantial growth, reaching £2.4B in investments, particularly in oncology research. The region stands out for its concentration of prestigious research centres, academic institutions, and medical charities, contributing to the rapid expansion of the LHS industry, attracting significant investments, and hosting pioneering companies in oncology, rare disease, and advanced therapy medicinal products (ATMPs), like AstraZeneca, Autolus, GlaxoSmithKline, Horizon Therapeutics, Immunocore, and Oxford Biomedica ⁽³²⁾. Among the universities that support this cluster are University of Cambridge, University of Oxford, Imperial College London, King's College London, London School of Hygiene & Tropical Medicine, and University College London.
2. The LHS industry in Massachusetts, known as the BioPharma Hub, is experiencing significant growth, with a 13.2% increase in Biopharma employment between 2020 and 2021. Oncology is a key focus, constituting 34% of research projects, and Boston's Biotech sector offers abundant opportunities, with a diverse range of nearly 1,000 Biotech companies,

including Pharma giants like Biogen, Shire, and Takeda ⁽³³⁾. Some notable educational establishments involved in healthcare include Harvard University, Massachusetts Institute of Technology, Tufts University, and Boston University.

3. Biotech Bay, covering San Francisco Bay, Menlo Park, and Palo Alto in Northern California, is a vital cluster in the LHS sector. California, particularly in the Biotech Bay region, stands as a dominant force in life sciences, boasting global leaders, startups, and cutting-edge research facilitated by major universities like Stanford University, University of California Berkeley, and University of California San Francisco. The LHS sector in California generated \$472B and supported over a million jobs in 2023 ⁽³⁴⁾. Genentech, Amgen, Gilead, Illumina, and Biomarin have significant operations in Biotech Bay.
4. Medicon Valley is a leading international LHS cluster in Europe, spanning the greater Copenhagen region of eastern Denmark and southern Sweden. It is one of Europe's strongest LHS clusters, with many life science companies and research institutions located within a relatively small geographical area ⁽³⁵⁾. Some of Medicon Valley's universities include University of Copenhagen, Technical University of Denmark, Lund University, and the Karolinska Institute. Major biotechnology and pharmaceutical companies are headquartered there including Novo Nordisk, Lundbeck, and Genmab.

Table 12 below shows NI and IE life sciences capabilities benchmarked against these competing clusters for several different metrics for 2022 in the LHS sector. The Golden Triangle emerges as the largest cluster, boasting over 2.1 million employees in the LHS sector, reaching a sector value that approaches €91B, and hosting a staggering 3,700 companies. Following closely, the Biopharma Hub demonstrates substantial sector value and employment, with over €78B in sector value, more than 100,000 employees, and a company count exceeding 1,000. Meanwhile, the Biotech Bay commands a sector value exceeding €54B, employs

over 160,000 individuals in the LHS field, and hosts over 300 companies. IE performs well, with a sector value surpassing €45B, 102,000 LHS employees, and 375 companies. Medicon Valley, renowned for its contributions, boasts a sector value exceeding €5B, employs 2,800 individuals in the LHS sector, and houses 180 companies. NI reports a sector value of €1.3B, with 19,500 employees and 250 companies.

Additionally, the number of universities within each cluster underscores the academic backbone supporting research and innovation. Remarkably, the US clusters, the Biopharma Hub, and the Biotech Bay, collectively encompass 55 universities, underlining their robust academic foundation. Similarly, both

IE and Medicon Valley host nine universities each, whereas the Golden Triangle and NI involve six and two universities, respectively.

Finally, the R&D expenditure as a percentage of GDP offers valuable insights into the prioritisation of research and innovation within each cluster. Leading the sector are the Biopharma Hub and the Biotech Bay, demonstrating significant investment commitment, followed closely by the Swedish region of Medicon Valley. Denmark, the Golden Triangle, NI, and IE follow in descending order, reflecting varying degrees of investment emphasis across the clusters.

Table 12: Illustrating key international comparative metrics for LHS clusters

	Population (M)	Sector Value (€B)	Sector employees	Number of companies	Number of universities	R&D* spend as % of GDP
NI	1.91	1.30	19,500	250	2	2.3
IE	5.02	>45.00	102,000	375	9	2.0 †
Golden Triangle	10.06	90.93	2,100,000	3,700	6	2.4
Biopharma Hub	7.00	78.13	106,704	>1,000	35	3.5
Biotech Bay	0.81	54.06	158,449	>200	20	3.5
Medicon Valley	4.0	5.19	2,800	180	9	2.8/3.4 ♦

*Note – this percentage represents total R&D spend not just LHS.

†This figure is a percentage of modified GNI. ♦Denmark = 2.8% and Sweden = 3.4%

B: billion; GDP: Gross Domestic Product; GNI: Gross National Income; IE: Ireland; LHS: Life and Health Sciences; M: million; NI: Northern Ireland; R&D: Research & Development

Source: Hargreaves (2020) ⁽³⁶⁾, JLL Life Sciences (2023) ⁽³⁷⁾, GEN (2023) ⁽³⁸⁾, Peter (2023) ⁽³⁵⁾





5 Capturing the full potential of oncology and allied digital health

The previous sections highlighted that the general LHS sector in both NI and IE, while vibrant, is performing less well when compared to other leading LHS clusters. Investment in R&D, a supportive regulatory environment, access to talent, clustering and collaboration, infrastructure and facilities, market access and internationalism, and incentives and tax benefits have been cited as contributing to a thriving LHS⁽³⁹⁾. We interviewed key stakeholders involved in oncology and allied digital health operating on the island of Ireland to determine the key success factors for a thriving oncology and allied digital health sector (see the Case Studies below). All stakeholders agreed that there are pockets of excellence on the island of Ireland, but more could be done on a bi-national level to ensure that its full potential could be realised, details of which are discussed below. This section does not attempt to provide a comprehensive overview of key enablers to a thriving oncology and allied digital health sector, but rather as a pointer to key enablers that could/should be mobilised.

5.1 R&D funding

Research in oncology drives R&D activities in related fields such as genomics, bioinformatics, and digital health⁽⁴⁰⁾. This stimulates innovation, attracts research and VC funding, and has established NI and IE as potential leaders in these

areas. Recognising the imperative for strategic allocation of resources, representatives from Precision Oncology Ireland (POI; www.precisiononcology.ie), a large-scale SFI Strategic Partnership Programme, Future Medicines Institute (FMI), an initiative designed to operate as a “research hotel” facilitating rapid access to shared resources for companies, and have advocated for increased science funding in R&D. This strategic recommendation is viewed as pivotal in fostering the growth of a vibrant oncology and allied digital health sector. However, it is crucial to note that the need for heightened R&D investment extends beyond mere augmentation; it underscores the strategic utilisation of funds to enhance health and socioeconomic advantages for the island. This assertion gains significance in light of the previous section’s revelation that R&D funding as a percentage of GDP/GNI on the island of Ireland falls short of leading LHS clusters and the EU’s recommended target of 3%⁽⁴¹⁾. The recently published Lancet Oncology European Groundshot Commission also underscores the necessity for increased investment and appropriate prioritisation in cancer research funding in Europe. This recommendation aligns with the initiatives such as the Cancer Mission, Europe’s Beating Cancer Plan, the EU for Health Programme, Horizon Europe, and other programmes, which offer significant opportunities for research funding at the supra-regional scale⁽⁴²⁾.



In NI, R&D funding in the innovation and commercialisation arena is currently channelled through both Innovate UK and Invest NI. Invest NI offers support to companies looking to venture into R&D to enhance their products, customer base, and profitability. This includes financial aid for project definition, guidance on planning and defining R&D projects, assistance in obtaining R&D grants, and collaboration opportunities with industry, academia, and research bodies to mitigate risks and maximise rewards. Meanwhile, Innovate UK is dedicated to driving innovation and growth across the UK through targeted funding, expertise, and collaboration, to foster a dynamic ecosystem that fuels economic prosperity, tackles societal challenges, and positions the UK as a global leader in innovation.

In IE, research in the LHS sector in academia is currently funded mainly through SFI, which funds many programmes including SFI research centres, SFI strategic partnerships, fellowship and training programmes and challenge-based funding approaches ⁽⁴³⁾. Additional funding is available for (mostly) translational and clinical research in the oncology arena from the Health Research Board (HRB) and specific

cancer charities, such as the Irish Cancer Society (ICS) and Breakthrough Cancer Research. In addition, both the Industrial Development Authority (IDA) and EI provide R&D funding programs for multinational and indigenous companies respectively, including the DTIF.

In addition, companies can apply for funding through Horizon Europe, which allocates €8.25B for health, including personalised medicine, and €15.35B for digital, industry, and space initiatives. Within this framework, the European Innovation Council (EIC) plays a crucial role in supporting breakthrough innovations with significant scaling potential, particularly targeting Small to Medium sized Enterprises (SMEs), with 70% of the budget dedicated to this sector ⁽⁴⁴⁾.

A future and complementary body of work would be to map the funding given to companies via DTIF and from Europe to ascertain a complete picture of the oncology funding landscape on the island of Ireland.

5.2 Supportive infrastructure for early stage clinical trials

Clinical research trials are fundamental to healthcare innovation, because they translate cutting-edge science into effective treatments and improved patient outcomes. A supportive infrastructure for early stage clinical trials was cited by all the stakeholders interviewed as important in promoting a thriving oncology and allied digital health ecosystem on the island of Ireland. The establishment of a dedicated Phase 1 experimental medicine unit was recommended by **Carrick Therapeutics**. In NI, there is the Belfast Experimental Cancer Medicine Centre (ECMC), part of a UK network, facilitating investigator-led translation and early stage clinical evaluation in oncology ⁽⁴⁵⁾. The ECMC initiative is funded by Cancer Research UK (CRUK), the Little Princess Trust, the National Institute for Health and Care Research (NIHR) in England and the Departments of Health for Scotland, Wales, and NI Health and Social Care/Public Health Agency (HSC/PHA). A transformative development in NI, as part of the Belfast Region City and Growth Deal (BRCD), is iREACH (Institute of Research Excellence for Advanced Clinical Healthcare)-Health which will facilitate healthcare innovation by integrating clinicians, life scientists, data scientists, and industry partners to develop new diagnostic tests and treatments. iREACH-Health will develop cutting-edge clinical research facilities near Belfast City Hospital to expedite clinical trials, advancing life-saving innovations and hastening market access for companies ⁽⁴⁶⁾. A second innovative BRCD approach that is particularly relevant for digital health and innovation is Momentum One Zero, linking secure connected intelligence with industry challenges in the health and agrifood sectors.

In IE, a recently launched example is START Dublin, which is IE's first and only Phase 1 clinical trial site for cancer medicines and is physically located at and operated by the Mater Misericordiae University Hospital (MMUH) in conjunction with University College Dublin (UCD). The MMUH and UCD is partnering with START (South Texas Accelerated Research Therapeutics), a US physician-owned clinical trials group which is dedicated to finding and developing new cancer treatments ⁽⁴⁷⁾. Dublin was chosen as a location because of the increased need for overall cancer care in the regions and the availability of qualified oncologists.

5.3 Collaboration

Collaborations between academia, industry and healthcare professionals are important for innovation, knowledge transfer, skills development and risk mitigation of R&D, as highlighted by all the key stakeholders interviewed ⁽⁴⁸⁾. Indeed, FMI and POI could be excellent pioneering examples of strategic co-development and collaboration potential. POI is a consortium of 5 Irish Universities, 6 Irish Charities, and 7 industry partners aiming to develop new diagnostics and therapeutics for personalised cancer treatment and is part-funded by SFI. FMI has the potential to serve as a 'one-stop-shop', uniquely positioned to bring LHS companies, Health Innovation Research Alliance Northern Ireland (HIRANI), UU and Queen's University Belfast (QUB) together in pre-competitive and partner-specific competitive research. The FMI will be strategically aligned with the research and economic development strategies of the Departments of Economy (DfE) and Health in Northern Ireland.

Industry-academic collaborations offer various benefits. These include the conduct of joint research projects, securing government funding, commercialising new technologies via spin-out companies, sharing resources such as specialised laboratories/data repositories/computing infrastructure, sharing experience such as regulatory and market access experience, providing opportunities for training and development, de-risking of research and ultimately enhancing productivity in new product/service development ^(49, 50, 51, 52, 53, 54).

In the area of oncology and allied digital health, it appears that there are many pockets of successful collaborative projects. For example, Almac have collaborated with researchers at QUB and the University of Cambridge, to validate a test that could enable clinicians to decide the most appropriate chemotherapy for early stage oesophageal cancer ⁽⁵⁵⁾. Furthermore, Almac and QUB have just been awarded a new early stage drug development initiative funded by the Biotechnology and Biological Sciences Research Council (BBSRC) Prosperity Partnership scheme called the Almac Discovery/QUB Centre of Excellence for Chemoproteomics ⁽⁵⁶⁾.



An example of a successful application to IE government funding is the HEALED Consortium, which secured DTIF Fund support of €6.8M as part of a 3-year, €10.5M programme to develop next generation cell therapies for cancer. The consortium comprises RemedyBio as programme lead, aCGT Vector, Trinity College Dublin, St James's Hospital, and the SFI Centre for Research Training (CRT) in Genomics Data Science at the University of Galway (UG). This group brings together deep capabilities

in mass-scale functional biology, good manufacturing practices (GMP) clinical deployment, clinical and tumour microenvironment expertise in cancer, and molecular data analytics to create a world first in near-patient, personalised, functional cancer therapeutics ⁽⁵⁷⁾.

Finally, it is also worth highlighting **AilseVax**, as a spin out company focusing on cancer vaccines from both QUB and TCD, demonstrating that novel approaches can be developed to create collaborative commercial enterprise in oncology through an all island approach ⁽⁵⁸⁾.

5.4 Investment in essential infrastructure

Oncology and allied digital health requires supportive infrastructure such as biobanks, access to electronic health records (EHRs) and the ability of AI and machine learning to analyse large-scale genomic data, identify biomarkers, and predict treatment responses ^(59, 60). Investment in essential infrastructure, particularly around data, was cited by POI, **Diaceutics**, and **Akkure** as essential for a thriving oncology and allied digital health sector. Despite the growing adoption of AI in oncology and digital health, challenges remain, including data privacy concerns, regulatory hurdles, and the need for interoperability standards ^(61, 62). Essential infrastructure is required which gives patients ownership of their EHRs, thereby empowering them to actively manage their health, improve care coordination, and enhance privacy and control over their data ^(63, 64).

Recently, NI has adopted an EHR strategy which is being rolled out initially with the South Eastern HSC Trust. This system, known as 'EncompassNI' and co-developed with Epic, a part of the **Clanwilliam Health** group, offers real-time, up-to-date patient information to healthcare providers. It empowers them to make efficient, effective, and patient-centred decisions ⁽⁶⁵⁾. In IE, the EHR programme is well behind but is finally under development, with the potential to link with general practitioner notes, hospital tests, clinical data, and even external data from devices such as wearable monitors from the aspect of oncology and allied digital health ⁽⁶⁴⁾. Biobanks have similar privacy, consent, and ethical issues as EHRs but additionally infrastructure, sample



5.5 Shared Infrastructure

Many of the key stakeholders interviewed cited difficulties in knowing where and what to do when conducting early stage clinical research on the island of Ireland. An all-island “one-stop shop” which facilitates rapid access to registration of clinical trials, contracts, sharing resources and expertise as well as drawing down funding for these activities was recommended. AICRI strives to connect complementary regional initiatives like POI and FMI within an all-island industry-academic framework, enabling cancer researchers and innovators across the island of Ireland to collaborate, while also fostering connections with colleagues in the US and globally. An overarching All-Island Oncology Innovation Cluster is highlighted as a shared opportunity that would help drive innovation in the sector.

handling, and quality control require significant resources, while securing financial resources for long-term sustainability can be difficult ⁽⁶⁶⁾. Moreover, the cancer biobanking infrastructure in IE is significantly more fragmented than that in NI, which has a centralised resource (NI Biobank).

Despite persistent challenges in implementing and adopting AI, NI and IE governments are actively integrating healthcare into their national AI strategies and vice versa ^(67, 68). This entails fostering public trust in AI as a service, cultivating skills and talent through institutions such as Momentum One Zero and the Centre for Digital Healthcare Technology (CDHT) in NI and the Centre for Applied Data Analytics Research (CeADAR) and Insight in IE. Furthermore, companies and research institutions across the island of Ireland are embracing AI to enhance productivity, necessitating the establishment of a secure infrastructure, such as the SFI data analytics research centre Insight (Dublin and Galway), indigenous companies such as **Sonrai Analytics** (Belfast) and **Deciphex** (Dublin) or large corporations based in Ireland, **Dell** (Cork, Dublin, Limerick), **Fujitsu** (Belfast, Derry, and Swords), **Microsoft** (Dublin), and **Siemens Healthineers** (Swords).

5.6 Case studies

We conducted six case studies to gain insights into various initiatives shaping the oncology and allied digital health landscape on the island of Ireland. These case studies were chosen to represent a diverse range of organisations and perspectives from both NI and IE, reflecting the multifaceted nature of the industry-academic collaborations and research efforts in this field.



CASE STUDY 1: Future Medicines Institute (FMI)



Professor Chris Scott (Dean of Research, Medicine, Health, and Life Sciences, QUB) is academic lead of the FMI initiative. Prof. Scott has an internationally renowned track record in both academic and commercial translational science and developing/de-risking next therapeutic approaches. His group also works extensively on cancer, and in particular antibody and nanomedicine-based therapeutic approaches, licencing technologies to companies in NI, IE and US. He is the scientific co-founder of four drug development companies. Before becoming Dean, he was Director of the Patrick G Johnston Centre for Cancer Research (2018-2022). Prof. Scott was a member of the Medical Research Council (MRC) developmental pathway funding scheme (DPFS) and is a member of the Engineering and Physical Sciences Research Council (EPSRC) Healthcare Technologies Scientific Advisory Team and has regularly contributed to UK Research and Innovation (UKRI) translational strategies in advanced therapeutics.

What is the Future Medicines Institute (FMI)?

FMI is the joint vision of the NI Precision Biomarkers and Therapeutics Consortium; a group of industry partners and both NI universities, working seamlessly together to co-create a dynamic hub where industry, academia and healthcare professionals converge. FMI aims to develop new technologies, drive productivity and derisk R&D efforts through collaborative working and sharing of technologies and resources for independent business needs, resources and capabilities, transforming NI's potential in development of therapeutics and diagnostics capabilities. Under the planned model, FMI will operate as a "research hotel", allowing rapid access of companies to shared resources, expertise, equipment and skills training. This initiative will synergise with the Belfast Region City and Growth Deal (BRCD) and other growth deals planned in the NI region to enhance productivity of companies operating in the LHS sector. FMI, whose initial funding is under review, is seen

by the sector as a crucial enabler to drive development of new technologies that can be clinically evaluated in the new BRCD-supported iREACH-Health, the Centre for Healthcare Technologies (CDHT) and the digital transformation hub, Momentum One Zero.

What are the goals of FMI?

FMI aims to provide shared capacity, capabilities, expertise, and skills training to allow company partners to enhance their own specific R&D agendas and ramp up R&D productivity in NI. Companies, from start-ups to large-scale organisations, can tap into a wealth of expertise from clinicians and academics. Additionally, it is hoped that FMI will allow better access to biobanks, product development/analysis, and equip researchers with future skills. The overall goal is to generate new therapies and diagnostics through an integrated pathway pipeline.

How can FMI leverage much needed VC funding for the sector in NI?

VC funding is contingent upon NI demonstrating a robust track record of commercialisation from both the industry sector and start-up ecosystem, provided through academic collaboration/leadership. FMI stands poised to streamline the process for SMEs looking to promote indigenous drug development, thereby facilitating access to crucial funding opportunities, using the combined knowledge and experience of FMI partners to help others bring products through development "valleys of death" and ultimately delivering new solutions to improving outcomes for patients.

What new therapeutic approaches could FMI help support?

Whilst the immediate goals of FMI will be to enhance R&D productivity for member companies, FMI will also be ideally placed to embrace and drive new advanced therapeutics, including cell therapies (e.g. CAR-T), gene delivery and genetic engineering technologies. NI already has world-class discovery centres that are engines for international quality discovery research in these areas such as Wellcome Wolfson Institute for Experimental Medicine and the Patrick G Johnston Centre for Cancer Research at QUB. These research centres focus on clinically-relevant research through close collaboration with the Department of Health and are already enabling development of new technologies that could be commercialised much more quickly and competitively through leveraging the capabilities of FMI and other initiatives such as the Precision Medicine Centre of Excellence (QUB; centre at forefront of next generation digital pathology), the Almac-QUB Chemoproteomics Centre of Excellence and the Personalised Medicine Centre (UU). FMI will play a key role in developing new areas such as cell and gene therapies as they emerge, coordinating commercial, health and academic expertise supporting early Technology Readiness Levels (TRL) R&D before products can be evaluated in iREACH-Health or CDHT and other City and Growth Deal initiatives across NI. Furthermore, there are collaboration opportunities with IE, which can enhance knowledge exchange and resource sharing, further augmenting the advancement of innovative therapies in the region.

How would you further collaboration between NI and IE?

There is clear potential for FMI to collaborate directly with companies across IE, as well as strategic partnerships with SFI centres or the National Institute of Bioprocessing Research and Training (NIBRT) that can lead to excellent non-replicative synergies across Ireland to enhance R&D culture, productivity and workforce planning. Furthermore, establishment of all-island clinical trial collaborations can ensure continuity and seamless collaboration in biomedical research and drug development.



CASE STUDY 2: Carrick Therapeutics



Carrick therapeutics

Dr Ash Bahl is the Chief Scientific Officer at Carrick Therapeutics, a clinical-stage biopharmaceutical company focused on oncological therapy. Dr Bahl has delivered over 10 compounds into clinical development from his leadership of drug discovery projects in R&D. Dr Bahl has also helped in establishing pioneering collaboration with the Medical Research Council and the National Institutes for Health/National Center for Advancing Translational Sciences (NIH/NCATS) in drug repositioning.

What are your thoughts on the oncology ecosystem in the island of Ireland?

While Ireland has robust academic research, there is a comparative lack of infrastructure for early-phase clinical trials and associated biomarker testing, when benchmarked versus countries such as US, Britain, and Australia to name a few. This deficit poses a significant hurdle in transitioning promising research into clinical applications.

Does this relate to biomarker assessment and/or study design?

There are challenges designing biomarker-oriented Phase 1 trials and it is important to correlate biomarker responses with patient outcomes. Additionally, we need rigorous methodologies to identify biomarkers predictive of treatment efficacy.

Is there a role for machine learning and/or artificial intelligence in these trials?

The potential of these technologies is transformative; however, we currently rely on traditional statistical methods due to the limited patient population size in early-phase trials.

How would you describe the infrastructure of the ecosystem?

Academic collaboration and global networking play pivotal roles in propelling precision oncology forward. I cannot overstate the significance of both academic support networks and the remarkable flexibility and adaptability demonstrated by some companies in nurturing partnerships, both at home and on the global stage.

What is top of your wish list?

1. Increased venture capital funding to support spinouts and innovative research endeavours.
2. Establish dedicated Phase 1 experimental medicine units, mirroring successful models from other countries, particularly focusing on Drug-Companion Diagnostics.
3. Develop an integrated academic network that functions cohesively to bridge the gap between research and clinical applications.

CASE STUDY 3: Precision Oncology Ireland (POI)



Professor Walter Kolch is Director of Precision Oncology Ireland (POI), a large-scale SFI Strategic Partnership Programme. Prof Kolch is internationally recognised for cutting-edge research using systems approaches to understand signalling networks and is ranked 4th in the world in precision oncology, and 10th in systems medicine (Google Scholar). Through his leading involvement in pan-European strategic initiatives, including the ELIXIR Research Infrastructure for Life Science Information programme, Prof. Kolch has played a central role in the development of precision oncology and medicine policy and funding at both national and international level.

What are your thoughts on the oncology support network on the island of Ireland?

The oncology support network on the island of Ireland shows promising pockets of excellence, exemplified by initiatives like the POI consortium. However, to maximise impact, there is a pressing need for a comprehensive whole-island approach. Challenges persist, particularly in integrating genomics and genomic sequencing into routine clinical practice. Additionally, bridging the gap between research and patient care remains a priority, highlighting the importance of fostering closer collaboration and synergy between industry, researchers, and patients.

What are the current barriers to genomic sequencing in IE?

There are several obstacles hindering the integration of genomic sequencing into clinical practice in Ireland. These barriers include insufficient infrastructure and a shortage of skilled personnel. To overcome these challenges, I would advocate for investment in essential infrastructure, such as national biobanking facilities and robust IT systems.

Additionally, this underscores the need to expand Phase 1 clinical trials to accelerate research and facilitate the translation of genomic insights into clinical applications.

What steps could be taken to minimize and /or eliminate these barriers?

This is partly due to the existing reliance on industry-academic collaborations, driven in part by the scarcity of funding within the public system, which prompts academics to seek partnerships with industry. I must emphasise the importance of safeguarding the autonomy of basic research and warn against excessive dependence on industry collaborations; indeed, there is a need to strike a better balance in industry-academic partnerships in IE. Moreover, I would further stress the urgent need for increased science funding in IE. The country has a low allocation of R&D spend as a proportion of GDP in relation to scientific research compared to EU targets. Finally, I would underscore the vital role of investing in research infrastructure to support the growing biotech sector, emphasising the critical necessity for enhanced financial support and structural backing to drive scientific progress in IE.

Are there any further obstacles to IE realising its potential as an Oncology Innovation Cluster?

The potential for industry-academia collaboration in advancing research and development within precision oncology and digital health is perceived as limited. This is primarily due to two key factors: Firstly, many pharmaceutical companies operating in IE primarily focus on manufacturing activities rather than R&D, which restricts opportunities for collaboration on innovative projects. Secondly, digital industries, crucial for driving advancements in digital health, typically seek access to high-quality clinical data. However, the lack of comprehensive EHRs in IE presents a significant barrier, limiting the availability of the necessary data for collaborative initiatives. Overall, these constraints hinder the full realisation of the potential for industry-academia collaboration in advancing research and development within precision oncology and digital health in IE.

CASE STUDY 4: Diaceutics



Diaceutics

Better Testing, Better Treatment

Peter Keeling, the founder of Diaceutics, boasts over thirty years of expertise in international healthcare. A trailblazer in personalised medicine commercialisation, he foresaw its pivotal role in reshaping the pharmaceutical industry. Since Diaceutics' establishment in 2005, Peter's leadership has propelled the company to collaborate with 39 top pharma companies, including the top ten globally. His strategic guidance saw the launch of DXRX- The Diagnostic Network®, the world's inaugural diagnostic commercialisation platform, which has helped to steer Diaceutics to the forefront of innovative solutions, enabling pharma companies to optimise global diagnostic testing.

Could you contrast your experience with the US ecosystem versus the ecosystem on the island of Ireland from the perspective of precision oncology and allied digital health?

Regrettably, the island of Ireland lacks connected infrastructure, and accessing data in NI proves notably restrictive compared to the US, where Diaceutics routinely uploads data nightly to its data lake. Moreover, both international and local transport networks could benefit from enhancement. Lastly, our network of academic collaborators on the island of Ireland is not as extensive as desired.

What factors have contributed to the success of Diaceutics?

When discussing Diaceutics' success factors, I would underscore the significance of several key elements: research into their business model, engagement

with pharmaceutical customers, experiential learning, development of data capabilities, establishment of lab networks, and securing funding through initial public offering (IPO). I would particularly emphasise the critical role of recruiting quality individuals in maintaining sustained success.

What suggestions do you have for removing barriers to data access?

Once privacy and security issues around patients' data have been addressed, the system of change itself needs to be driven by patients and, by that, I mean patient advocacy groups. The digital health aspect of precision oncology can then underpin cost effective care.

Do you think an All-Island Innovation Oncology cluster would progress research on the Island of Ireland?

Globally, I haven't encountered many instances where clustering has proven effective. However, despite my scepticism regarding its efficacy, I acknowledge the immense value of industry-academic collaboration in addressing the complex challenges posed by oncology. A first step in this direction would be a greater focus on the efficient implementation of precision medicine oncology using Irish clinical infrastructure as a test bed.

CASE STUDY 5: Akkure



Akkure

Professor Oran Rigby is the Founder of Akkure Genomics. Prof. Rigby, a Churchill scholar, is an Executive Medical Director, digital health entrepreneur and senior medical Intensivist sub-specialising in neuro-intensive care, with Australian and European postgraduate qualifications in Surgery, Aeromedicine, Tropical medicine & International health.

What are your thoughts on the digital health aspect of precision oncology?

The importance of patient ownership and control over their data cannot be over-emphasised, as well as the need for AI and machine learning to analyse large amounts of medical data in the generation of a 'digital twin'. A digital twin incorporates various data sources, such as genomic information, medical imaging, and clinical records, to create a comprehensive and personalised representation of the patient's disease.

How do we address the lack of comprehensive and standardized electronic health records (EHRs) infrastructure in IE?

Multiple EHR systems exist in IE, yet they often fail to meet standards. IE has a unique opportunity to start afresh, but it requires significant investment in a public-private consortium. Patients must be prioritised as stakeholders in overcoming system challenges such as fragmentation, interoperability, data quality, and privacy.

What are the benefits of creating an All-Island Innovation Oncology Cluster?

There are challenges of linking various precision oncology companies, I would stress the need for clusters, collaboration, and patient data incentives. I would highlight talent, funding, and research and development investment in precision healthcare, emphasising cluster importance. Additionally, we need to merge data sources, utilising AI for insights, and exploring the potential for precision oncology networks in IE. These insights underscore the benefits of creating an All-Island Oncology Innovation Cluster, fostering collaboration, innovation, and leveraging technology for improved patient outcomes.

CASE STUDY 6: Almac



Professor Richard Kennedy is Global VP of Biomarker Development, Medical Director and CLIA compliant Laboratory Director at Almac Diagnostic Services. He is responsible for the application of the company's technology into medical practice. He graduated in medicine from Queen's University Belfast in 1995. As a post-graduate, he trained as a medical oncologist and received a PhD in Molecular Biology in 2004. From 2004-2007 he worked as an instructor in oncology at Harvard Medical School, USA, where he identified novel biomarkers and drug targets for cancer treatment. In August 2007 he joined Almac Diagnostic Services as the Medical Director of a CLIA compliant diagnostics laboratory and has been involved in the biomarker design and delivery for over 300 clinical trials. In 2012 he became

The McClay Professor of Medical Oncology at Queen's University of Belfast and established a research group focussed on various aspects of precision medicine. He continues to publish regularly in this field. He currently sits on the MATRIX NI Government science advisory panel and the Royal College of Physicians Faculty of Pharmaceutical Medicine Oncology Advisory group. He is a past member of the MRC Stratified Medicine Panel and the CR UK new agents committee.

What would be the greatest impact on an All-Island Oncology Innovation cluster?

Establishing a centralised all-island mechanism to coordinate clinical trials, advanced phase I trials, holds the potential to attract foreign investment. This mechanism would serve as a virtual one-stop-shop for a globally competitive clinical trial institute in precision medicine, with a focus spanning both countries. Leveraging the academic and industrial expertise in Northern Ireland and Ireland, this institute would aim to expedite the clinical trial and registration process for oncology drugs for major pharmaceutical companies in the UK and European markets.

What types of networks would you deem essential for developing such a cluster?

Utilising personal relationships within academia is crucial for fostering collaborations with industry. However, there is no uniform, formal process. To encourage such collaborations, it is imperative to establish appropriate funding mechanisms and ensure the protection of intellectual property (IP). This approach will serve as an incentive for partnerships between large pharma corporations, smaller biotech companies and academia and should include representation from both health services.



What are the key factors driving successful industry-academia partnerships in these sectors?

Building successful industry-academia partnerships in these sectors relies on a two-pronged approach: collaboration and support. This includes establishing shared goals and accountability, fostering open IP arrangements, and utilising funding and initiatives like KTPs to encourage active collaboration. Additionally, academia's focus on meeting timelines and industry's engagement in student placements, curriculum development and training are crucial for building trust and ensuring the program's effectiveness.

Have you any final thoughts?

It's paramount to emphasise the necessity of a clear, unified strategy in establishing an All-Island oncology cluster across

NI and IE. My suggestion would be the formation of a standing group of academic and industrial representatives within an All-Ireland institute. This should be led by an individual with industrial expertise, who can provide a clear narrative around oncology trial capabilities and act as a central point of contact for pharma and biotech companies. The group would coordinate efficient communication and collaboration between the various partner organisations to maximise the benefits to biopharma companies from their shared expertise, facilitating inward investment and ensuring the success of the oncology cluster initiative. Ultimately, it should be the patients who are the key benefactors of such a strategy, who can benefit from access to cutting edge oncology clinical trials and new therapeutics that might have otherwise been unavailable, thereby prolonging health and wellness in both NI and IE.

Reflection

The case studies provided valuable insights into the challenges and opportunities within the oncology and allied digital health sectors in Ireland. Key learnings include the importance of fostering industry-academic partnerships, addressing barriers to data access and infrastructure, and the potential for collaboration to drive innovation and progress. These insights will inform future strategies and initiatives aimed at advancing cancer research and innovation and patient care on the island of Ireland.



Medical history
Physical exam
Vital signs
Lab tests
Imaging
Treatment plan
Follow-up

Male
Female
Wheelchair

Medical history
Physical exam
Vital signs
Lab tests
Imaging
Treatment plan
Follow-up

Medical history
Physical exam
Vital signs
Lab tests
Imaging
Treatment plan
Follow-up



6 Recommendations

There is now a unique opportunity to build on the solid foundation of a thriving LHS sector on the island of Ireland to create a sustainable, high performing, agile and innovative oncology and allied digital health sector. Based on the review of the oncology and allied digital health landscape and interviews with key stakeholders, a series of outline recommendations are provided. It was beyond the scope of this project to expand further on these recommendations, in terms of strategic developments required and how these recommendations could be operationalised. This could be explored in a future research project.

6.1 All-Island Oncology Innovation Cluster

NI and IE aspire to establish themselves as global leaders in the LHS sector, prioritising key factors such as access to finance, regulatory frameworks, skill development, manufacturing capabilities, and international trade. However, the current lack of a strong focus on clustering is a potential gap in respective strategies relating to this sector. Clustering, which concentrates expertise, infrastructure, skilled individuals, collaborators, and investors, is crucial for driving innovation and success in industries like life sciences. We have identified several LHS Clusters globally in this report; the Golden

Triangle, Biopharma Hub, Biotech Bay, and Medicon Valley, but there are many more. These clusters bring together academia, industry, public bodies, funders, regulators, and investors, fostering collaboration and innovation. A cluster organisation would take these groupings to the next level, enabling all partners – but particularly innovative start-ups, spin-outs and SMEs – to realise the full benefits of being located within a cluster⁽⁶⁹⁾. Such an organisation would play a key role in facilitating collaboration and coordination, driving economic growth, attracting investment, and advocating for cluster interests. Therefore, it is crucial to recognise the significance of an oncology cluster and to support its organisational structure to fully capitalise on cross-border opportunities. A cluster manager would play a pivotal role in facilitating networking among companies and academia, fostering stronger industry-research connections, bolstering R&D capabilities, identifying emerging market prospects, pinpointing new product concepts and demands, cultivating a supportive community, and enhancing international engagement.

An All-Island Oncology Innovation Cluster would also leverage the existing strengths and synergies within both NI and IE, while effectively addressing any identified areas for improvement. NI has strengths in developing indigenous companies, in digital health and biobanking and in diagnostics, while IE has strengths in digital, and drug manufacturing. The

goal of an All-Island Oncology Innovation Cluster would be to foster collaboration and resource sharing between research institutions, companies, healthcare providers, investors, and government agencies — a key enabler identified in the previous section. While programmes like POI and the establishment of FMI will undoubtedly enhance collaboration and resource sharing, their reach could be expanded and fortified further to ensure that the expected growth in the oncology and allied digital health sector is realised on the island of Ireland.

The All-Island Oncology Innovation Cluster could emulate the model of the POI and the proposed FMI initiatives, expanding their core membership to encompass stakeholders from both NI and IE. Industry partners could represent each of the five key sectors: device, diagnostic, digital, discovery, and drugs. The benefits to industrial partners are multifaceted, including access to talent and expertise, collaborative networking opportunities, shared resources and infrastructure, funding and investment channels, regulatory and policy support, as well as enhanced market visibility and reputation.

The shared resources within the cluster would address specific challenges such as clinical trial recruitment, data management and analysis, IP protection (e.g., through a research hotel model where companies retain their IP while paying for access), and market access and reimbursement hurdles. Establishing mutual recognition agreements to ensure clarity and fairness in commercialisation efforts may overcome any IP challenges.

6.2. Supportive infrastructure

There exists a pressing need for the establishment of clinical genomic sequencing capabilities on the island of Ireland and the corresponding staff to operate them efficiently, ensuring swift turnaround times for the treatment of patients' tumours. Addressing the challenge in terms of access to secondary data for research in NI and the lack of a Unique Patient Number and joined-up EHR systems in IE are also crucial steps to developing a leading oncology and allied digital health sector. Additionally, the establishment of a National Biobanking infrastructure on the island of Ireland, learning from the NI Biobank model, coupled with a robust information technology

framework, is essential. An all-island dedicated Phase 1 experimental medicines unit, building on the ECMC at QUB and START initiative in MMUH/UCD, is also required where micro, small, and medium-sized companies can evaluate their novel treatments under clinical partnership. Maximising the all-island impact of iREACH-Health is also relevant in this context.

6.3 R&D funding

NI and IE significantly lag behind most Western nations and leading LHS clusters concerning R&D funding. In 2021, the R&D spend specifically for LHS in NI amounted to €21.2M ⁽⁷⁰⁾. This amount is notably lower than the €62.2M invested in IE during 2021, even when considering the population difference between the two regions ⁽⁷¹⁾. To bolster the necessary infrastructure, a significant boost in R&D funding is imperative, increasing to at least 3.5% of GDP. This commitment also aligns with the goals outlined in NI's DfE "10x: An Economic Vision", which aims to elevate R&D expenditure by 55% ⁽⁷²⁾. However, the IE government commitments to R&D show a modest 13% increase in spending by 2030, this would need to increase by 75% instead to align with NI ⁽⁷³⁾. However, there are ambitious plans in place to double business expenditure on R&D (BERD) by the same year, aiming to reach €6.8 B ⁽⁷³⁾.

Nonetheless, some promising signs are on the horizon in both NI and IE in terms of establishment of core building blocks for future success. Over the coming decade, NI is set to receive a significant injection of investment through four City and Growth Deals, the first of which will happen in the Belfast Region. This transformative package, funded jointly by the NI Executive, the UK government and with key involvement from QUB, UU, and the private sectors, will amount to over £1.2B. This funding will be further enhanced by contributions from the further education/private sector and other funding sources, including the £100M Complementary Fund provided by the NI Executive. These growth deals will in part fund oncology and digital health projects in iREACH-Health and Momentum One Zero in Belfast and the Personalised Medicine Centre in Derry ⁽⁷⁴⁾.

The Programme for Government in Ireland (2021-2030) and the revised National Development Plan have outlined an ambitious vision for collaborative investment across the

island, aiming for enhanced connectivity, sustainability, and prosperity for all communities ⁽⁷⁵⁾. This vision is supported by a total commitment to all-island investment exceeding €3.5B up to 2030. Funding sources include the Government's Shared Island Fund, Project Ireland 2040 funds, resources allocated for North/South cooperation, and the PEACEPLUS programme, implemented in collaboration with the European Union, the UK Government, and the NI Executive.

The Shared Island Fund, allocated with a minimum commitment of €1B until 2030, is dedicated funding aimed at facilitating the realisation of all-island investment commitments and goals. The Government of Ireland is actively utilising the Shared Island Fund, collaborating with all-island partnerships, including the NI Executive, the UK Government, Local Authorities, educational institutions, and through comprehensive island-wide funding initiatives. To date, almost €500M has been specifically allocated from the Shared Island Fund, with AICRI benefitting in very significant part to date primarily under the North-South Research Programme; albeit further substantive investment to facilitate fast-tracking of innovation in the oncology arena is required ⁽⁷⁶⁾.

The identified variances in available funding and research support mechanisms between the two regions may create disparities in the resources available for collaborative projects, potentially affecting the scale and scope of initiatives. While the oncology support ecosystem is currently larger in IE, when accounting for population differences, parity between NI and IE should be established when the iREACH Health (facilitating excellence in clinical research) and Momentum One Zero (ensuring connected intelligence in digital health), reach their operating potential in 2026 and 2027, respectively.





7 Conclusion

IE and NI have a rich life and health sciences heritage. This is evidenced by the fact IE is host to 19 of the top 20 global pharmaceutical companies and 14 of the world's top 15 medical device companies ^(77, 78). NI's LHS sector is also thriving, playing host to 250 companies and is worth £1.4B to the NI economy ⁽⁷⁹⁾.

As cancer therapy becomes increasingly personalised and tailored to individual patients, it is important that we ensure we capitalise on maximising the potential growth in oncology and allied digital health sectors on the island of Ireland. Seizing the opportunities that oncology and allied digital health has created, provides economic opportunities by attracting investment, fostering entrepreneurship, generating high-value jobs in areas such as biotechnology, pharmaceuticals, and digital health and discovering lifesaving medicines for patients ⁽⁷²⁾.

This is the first landscape review of the oncology and allied digital health companies operating on the island of Ireland. It highlights a thriving oncology and allied digital health sector comprising 172 companies, which are a mixture of small and medium sized indigenous and large multinational companies. NI has a thriving indigenous sector with a focus on diagnostics and digital enterprises, as well as a relatively higher proportion of university spin-outs. IE, on the other hand, has a high concentration of large multinationals, and

a focus on drug manufacturing and digital supported by a strong research ecosystem. In addition, NI appears to have an advantage in scaling up university spin-outs to medium and large enterprises compared to IE. The reasons behind this, whether it is due to talent attraction to multinational corporations in IE, a preference for acquisition by larger entities, rather than scaling, insufficient engagement by academia and government, or other factors, warrant further investigation through more comprehensive research.

The oncology and allied digital health sectors have huge economic potential and have experienced considerable growth since the 1990s. They are part of over a 4 million strong global workforce and are forecasted to experience CAGRs of between 6% and 20%, with the fastest growing sectors projected to be diagnostics and digital. The global cumulative revenue of all companies operating on the island of Ireland, who offer oncology and allied digital health products and services, reached just under €2.4T in 2022, and it is projected to soar to over €10.7T by 2032.

Benefitting from this growth in the oncology and allied digital health relies on identifying key enablers in the oncology and allied digital health ecosystem, as highlighted in interviews with key stakeholders and benchmarking with leading LHS clusters around the world. Key enablers identified include an increase in R&D funding, more collaboration between

industry, academia, clinicians and research institutions, investment in essential infrastructure such as biobanks, clinical genome sequencing, EHRs, a dedicated Phase 1 experimental medicine unit and a one-stop-shop, all-island approach to drive industry-academia partnerships that deliver health, economic and societal benefits.

Therefore, our key recommendations are:

- ▶ **Create an All-Island Oncology Innovation Cluster to consolidate and promote the relative strengths in research, innovation and implementation in NI and IE, foster all-island and international collaboration, attract talent and investment including venture capital. This cluster should be resourced to stimulate investigation of cross-border opportunities with the aim of promoting cross-border trade and R&D and facilitating economic growth on the island of Ireland.**
- ▶ **Increase R&D funding to 3.5% in line with other Western countries and in line with leading Life and Health Science (LHS) clusters around the world.**
- ▶ **Develop joint academic/industry/health infrastructure to facilitate better collaboration, knowledge transfer, skills and innovative diagnostics and therapeutics, e.g. Future Medicines Institute (FMI).**
- ▶ **Address critical gaps in clinical infrastructure such as expansion of experimental Phase I trials.**
- ▶ **Solve critical gaps in digital health infrastructure including the establishment of EHRs in IE and better access to patient data in NI.**
- ▶ **Explore the opportunities for robust all-island partnerships through the Shared Island Unit, PEACEPLUS and Northern Ireland City and Growth Deals.**

These recommendations align with various industrial and R&D strategies in IE as espoused by EI, Ibec, the IDA and the HRB; whose focus is on promoting the growth of the multinational and indigenous LHS sectors and

increasing expenditure on R&D through partnership and collaboration ^(73, 80, 81). In NI, these recommendations align with the goals outlined in NI's DfE "10x: An Economic Vision", which prioritises the LHS sector and aims to elevate R&D expenditure by 55% and Innovate UK's attempt to stimulate cluster development in NI ⁽⁷²⁾. Additionally, there is alignment with PEACEPLUS's strategic programme of cross-border research in growth areas such as LHS and AI, healthcare service delivery and intervention trials, and enhancing cross-border collaboration in sectors such as healthcare through staff exchanges and training ⁽⁸²⁾. Meanwhile, in IE, "Impact 2030 Ireland's Research and Innovation Strategy" stresses a strategy to foster an environment of inclusion and engagement in the health research and innovation community while promoting all-island, EU, and global collaboration ⁽⁷³⁾. Impact 2030 aims to maximise the research and innovation contribution to sustaining and furthering the health and wellbeing of the people of Ireland ⁽⁷³⁾.

It is also worth pointing out that clustering is not a new concept on the island of Ireland. HIRANI's objective is to collaborate closely with NI's universities, public sector entities, and local industries, the organisation serving as a unified voice to empower the region's LHS sector, facilitating collective promotion and strategic positioning on both national and international stages. Additionally, the AI Healthcare Hub at UCD has joined Ireland's Connected Health and Wellbeing Cluster, supported by EI, aimed at fostering collaboration between technology and health sectors to drive innovation and productivity, facilitating interaction among industry, academia, healthcare providers, and enterprise support agencies ⁽⁸³⁾. Furthermore, the development of all-island clusters is one of the strategic priorities of InterTradeIreland whose mission is to deliver collaborative, all-island trade and business development initiatives that drive productivity, jobs and growth ⁽⁸⁴⁾.

To conclude, the island of Ireland has the potential to be a global leader in oncology and allied digital health research and commercialisation. Adopting the recommendations of this report will empower a paradigm shift in oncology and allied digital health activities on the island of Ireland, capitalise on the global growth in oncology innovation and ensure enhanced health and wealth on this island.



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10 Appendix

10.1 Support ecosystem

Table 13: Oncology support Ecosystem of hospitals, academic and research centres, and charities on the island of Ireland

COMPANY	Country	Function
Action Cancer	NI	Charity
ADAPT	IE	Research
AMBER	IE	Research
APC	IE	Research
Beaumont RCSI Cancer Centre	IE	Hospital
Bioinnovate Ireland	IE	Research
Breakthrough Cancer Research	IE	Charity
Breast Cancer Ireland	IE	Charity
Cancer Centre	NI	Hospital
Cancer Focus Northern Ireland	NI	Charity
CeADAR	IE	Research
Centre for Digital Healthcare Technology	NI	Research
Centre for Food and Drug Discovery	NI	Research
Centre for Public Health	NI	Research
Children's Health Ireland at Crumlin	IE	Hospital
Cork University Hospital	IE	Hospital
Cúram	IE	Research
Dublin City University	IE	Academic
EIT Health	IE	Research
Friends of the Cancer Centre	NI	Charity
HRB Clinical Research Facility	IE	Research
IPIC	IE	Research

Table 13: (continued)

COMPANY	Country	Function
Irish Cancer Society	IE	Charity
Lambe Institute for Translational Research	IE	Research
Lero	IE	Research
Leukaemia & Lymphoma NI	NI	Charity
Limerick Digital Cancer Research Centre	IE	Research
Mater Misericordiae University Hospital	IE	Hospital
National Breast Cancer Research Institute	IE	Charity
National Children's Research Centre	IE	Charity
National University of Ireland, Galway	IE	Academic
National University of Ireland, Maynooth	IE	Academic
NIBRT	IE	Research
NIPANC	NI	Charity
North West Cancer Centre	NI	Hospital
Nova UCD	IE	Research
Oesophageal Cancer Fund	IE	Charity
Patrick G Johnston Centre for Cancer Research	NI	Research
Personalised Medicine Centre	NI	Research
Precision Medicine Centre of Excellence	NI	Research
Precision Oncology Ireland (POI)	IE	Research
Queen's University Belfast	NI	Academic
Radiation and Environmental Science Centre	IE	Research
Royal College of Surgeons Ireland	IE	Academic
St Vincent's University Hospital	IE	Hospital
Synthesis and Solid State Pharmaceutical Centre (SSPC)	IE	Research
Technological University of The Shannon	IE	Academic
Trinity Biomedical Sciences Institute	IE	Research
Trinity College Dublin	IE	Academic
Trinity St. James' Cancer Institute	IE	Hospital
Tyndall National Institute	IE	Research
UCD Conway Institute	IE	Research
Ulster University	NI	Academic
University College Cork	IE	Academic
University College Dublin	IE	Academic
University Hospital Galway	IE	Hospital
University Hospital Waterford	IE	Hospital
University of Limerick	IE	Academic

Note: Academic institution denotes university while research centre is usually associated with university but in this case has a major focus on oncology or allied digital health

AMBER: Advanced Materials and BioEngineering Research; APC: Alimentary Pharmabiotic Centre;
 CeADAR: Centre for Applied Data Analytics Research; EIT: European Institute of Innovation and Technology;
 HRB: Health Research Board; IE: Ireland; NI: Northern Ireland; NIBRT: National Institute Bioprocessing Research and Training;
 NIPANC: Northern Ireland Pancreatic Cancer; POI: Precision Oncology Ireland; RCSI: Royal College of Surgeons in Ireland;
 SSPC: Synthesis and Solid State Pharmaceutical Centre; UCD: University College Dublin.

10.2 Indigenous and multinationals with a presence on the island of Ireland

Table 14: Oncology and digital health products/services available from companies on the island of Ireland

COMPANY	Country	Product Services
42 Genetics	NI	NGS data analysis
Abbott	IE	FISH
AbbVie	IE	MoAbs, TKIs
ACGT Vector	IE	CAR-T Cell Therapy, mRNA
Agilent Technologies	IE	CRISPR, Immunotherapy, Genomics, Proteomics, Metabolomics
Ailsevox	NI	Cancer vaccines
Akkure	IE	AI cancer trials
Almac Group	NI	CDx, NGS, liquid biopsy
Altamira Therapeutics	IE	RNA therapeutics
Altan Pharma	IE	Pharmaceuticals
ALX Oncology	IE	Immunotherapy
Amazon	IE	Cloud computing and VTBs
Amgen	IE	MoAbs, TKIs
Amneal	IE	MoAb
Amply Discovery	NI	Drug discovery
Andor Technology	NI	Imaging
Apple	IE	Apps, Devices
ARC Regulatory	NI	CDx discovery
Arisglobal	IE	Drug development solutions
Aspen Pharmacare	IE	Chemotherapeutics, MoAbs, TKIs
Astellas	IE	MoAbs, TKIs, Hormonals, Chemotherapeutics
AstraZeneca	IE	Immunotherapy, MoAbs, TKIs
Atturos	IE	Diagnostic solutions
Avectas	IE	CAR T-Cell delivery
Avellino Labs	NI	Liquid and tissue biopsies
Aviceda Glycotech	NI	Immunotherapy
Axis Bioservices	NI	Drug discovery
Azure Pharmaceuticals	IE	Chemotherapeutics
Bayer	IE	Immunotherapy, Radiopharmaceuticals, TKIs
BD Medical	IE	Flow cytometry, single cell multiomics, bioinformatics
Bio Pharma Technical Consulting	IE	Cell & gene therapy
Biopanda Reagents	NI	Cancer antigen
Biostor	IE	Biospecimen, biostorage, cold chain logistics
Blue Zinc	NI	Patient care pathway
Bluebridge Technologies	IE	Digital Therapeutics, Digital Diagnostics, Digital Medical Devices
Boehringer Ingelheim	IE	Immunotherapy, TKIs
Boston Scientific	IE	Ablation, Embolization, Catheters, and Stents
Bristol Myers Squibb	IE	CAR T-Cell, Immunotherapy, MoAbs, TKIs
Carefolk	IE	EHRs, Data analytics
Carrick Therapeutics	IE	TKIs
Celerion	NI	Clinical trials, consultancy
Cell Stress Discoveries	IE	Research
Cellix	IE	Cell Analysis

Table 14: (continued)

COMPANY	Country	Product Services
Celtic Biotech	IE	Snake-venom derived cancer therapies
Charles River Laboratories	IE	CRO services, Immunotherapy tumour assays
Ciga Healthcare	NI	Cancer antigen
Cirdan	NI	Imaging
Clanwilliam Health	IE	EHRs
Clindox	IE	Clinical data and associated medical devices
Cook Medical	IE	Endoscopy, urology
Cosmo Pharmaceuticals	IE	Treatments for gastro-intestinal diseases and dermatological conditions.
CTEP	IE	RWD
CV6 Therapeutics	NI	DNA Uracilation agent
Daiichi Sankyo Co.	IE	MoAbs, TKIs
Danaher	IE	Omics microarrays and multiplex antibody-based assays
Deciphex	IE	Digital Pathology/AI
Dell	IE	AI, digital twin technology
Diaceutics	NI	Data analytics, discovery
DMF Systems	IE	Remote monitoring
Dolmen Design And Innovation	IE	Stents for cancer patients
Eirgen Pharma	IE	OSD of MoAbs and chemotherapeutics
Elevar Therapeutics	IE	Immunotherapy, TKIs
Eli Lilly	IE	MoAbs, TKIs
Empeal Health	IE	Adherence, 360 degree view of health care, analytics
Epicapture	IE	Liquid biopsy
Ericsson	IE	Wearables, secure online consultations, and remote procedures
ERS Genomics	IE	CRISPR/Cas9 Gene Editing & Patent Licensing
Eurofins Biomnis	IE	Liquid biopsy
Exploristics	NI	Statistical analysis
Ferring	IE	Pharmaceuticals
Finn Therapeutics	NI	MoAbs
Fort Wayne Metals	IE	Endoscopy, biopsies
Fortress Diagnostics	NI	Cancer antigen
Frontend.com	IE	EHRs
Fujitsu	IE	AI for patients' individual cancer types and genomic variants
Fusion Antibodies	NI	MoAbs
G&L Scientific	NI	Consultancy
GE Healthcare	IE	Radiation oncology and imaging
Genebox	IE	WGS
GeneratR	NI	NGS data analysis
Genesis Automation In Healthcare	IE	Data Analytics
Genome Diagnostics	NI	Liquid and tissue biopsies
Gilead Sciences	IE	CAR T-cells, MoAbs, TKIs
GlaxoSmithKline	IE	Immunotherapy, TKIs, MoAbs
Google	IE	Mammography, genomics, imaging, diagnostics, wearables
Grapevine Solutions	IE	EHRs
HealthBeacon	IE	Adherence
HealthXL	IE	Digital health solutions

Table 14: (continued)

COMPANY	Country	Product Services
Helsinn	IE	Chemotherapeutics
Hitech Health	IE	CDMO ATMP
Hooke Bio	IE	Screening system for 3D microtissues
HP Technology	IE	Clinical workflow, digitization, clinical and diagnostic displays
I360 Medical	IE	Precision guided device
ICON	IE	Clinical Trials, Consulting
IMS Maxims	IE	EHRs
Inflection Biosciences	IE	TKIs
Ipsen	IE	TKIs
IQVIA	IE	Data analytics and Clinical research
Jabil Healthcare	IE	Liquid biopsy and wearables
Janssen	IE	MoAbs, TKIs, Hormonals, Chemotherapeutics
Jazz Pharmaceuticals	IE	TKIs
Jinga Life	IE	Self-management, EHRs
Kainos	NI	EHRs
KLAS Therapeutics	NI	Melanoma therapy
Kudos Health	IE	Data collection
Latch Medical	IE	Intradermal injection
Legend Biotech	IE	CAR T-Cells
Luminate Medical	IE	Control and prevent the side effects of cancer treatments
M&J Clinical Associates	NI	Consultancy
Malin	IE	Investment and support
Mallinckrodt Pharmaceuticals	IE	Chemotherapeutics
Manitex	IE	EHRs, clinical, Data analytics
Medica	IE	Ultrasound, CT, X-ray, and DXA
Medtronic	IE	Ablation and Endoscopy
MeiraGTx	IE	CAR-T cell therapy
Menarini Group	IE	Fusion protein, hormonal, chemotherapeutic, liquid biopsy, Assays
Merck	IE	Immunotherapy, MoAbs, TKIs
Mias Pharma	IE	Radiopharmaceuticals
Microsoft	IE	Data Analytics, ML, AI, digital pathology, cloud computing, Bio Model Analyzer
Mirai Medical	IE	Endoscopic electroporation
myPatientSpace	IE	EHRs for remote care
Novartis	IE	CAR T-cells, MoAbs, TKIs
NSilico	IE	Genomic analysis
Nua Solutions	IE	EHRs
O4 Research	NI	RCTs and RWE
Omnispirant	IE	Exosome anticancer delivery
Oncoassist	IE	EHRs
Oncoassure	IE	CDx
OneView Healthcare	IE	EHRs, telehealth
ONK Therapeutics	IE	CRISPR CAR NK-Cells
Optum (UHG)	IE	Predictive analytics, genomic data
Oracle	IE	Cloud computing, EHRs, RWD

Table 14: (continued)

COMPANY	Country	Product Services
Orion Health	NI	Patient care pathway
PCI Pharma Services	IE	Clinical trial services, advanced drug delivery
Pfizer	IE	MoAbs, TKIs, Hormonals, Chemotherapeutics
Philips Healthcare	IE	Lung cancer management, digital pathology, radiation oncology
Phillips-Medisize	IE	Scale-up manufacturer of CDx and wearables
Phion Therapeutics	NI	Cancer vaccines
Poolbeg Pharma	IE	Immunotherapy-induced CRS
Prestige Diagnostics	NI	ELISA
Priothera	IE	CAR-T Cell Therapy, HSCT
Quadrant Scientific	IE	EHRs software solutions
Radox	NI	CDx, NGS
Recordati	IE	TKIs, MoAbs
Regeneron	IE	Immunotherapy, MoAbs
Remedy Biologics	IE	Immunotherapy
Roche	IE	Immunotherapy, MoAbs, TKIs, chemotherapeutics
S3 Connected Health	IE	Therapy management, digital therapeutics
Sanmina	IE	Cancer treatment devices, CT scanners, X-ray equipment
Sanofi	IE	Immunotherapy, MoAbs, Ab-conjugates, hormonals
Sartorius	IE	Assays
SeqBiome	IE	Microbiomic analysis
Shorla Oncology	IE	Repurposing
Siemens Healthineers	IE	Data Analytics, AI, Imaging, Diagnostics
Sonotarg	NI	Chemotherapy microbubbles
Sonrai Analytics	NI	Data analytics
Stimoxygen	NI	Supplies oxygen to tumour
Symphysis Medical	IE	Drainage
Takeda	IE	TKIs
Teckro	IE	Clinical trials app
Terumo BCT	NI	Blood and cell processing
Teva	NI	Biosimilars
Tympany Medical	IE	Endoscope
Univ8 Genomics	NI	NGS
Valitacell	IE	Cell Therapy, MoAb analysis
Venn Life Sciences	IE	Clinical trial consultancy
Viatrix	IE	Chemotherapeutics, MoAbs, TKIs
Vitro Software	IE	EHRs
Vodafone	IE	DreamLab
Wellola	IE	Communication software between EHRs, wearables, etc
Wuxi	IE	CRISPR, Immunotherapy, Assays, Tumour Models, CDx, Data Analytics
Yarra Software	NI	EHR

AI: Artificial Intelligence; AR: Androgen Receptor; ATMPs: Advanced Therapy Medicinal Products; CAR: Chimeric Antigen Receptor; CDMO: Contract Development and Manufacturing Organisation; CDx: Companion Diagnostic; CRISPR: Clustered Regularly Interspaced Short Palindromic Repeats; CRS: Cytokine Release Syndrome; CT: Computer Tomography; ELISA: Enzyme-Linked Immunosorbent Assay; GR: Glucocorticoid Receptor; IE: Ireland; NI: Northern Ireland; NK: Natural Killer; OSD: Oral Solid Dosage; mRNA: messenger Ribonucleic Acid.





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