Title

PRISM for Cancer Outcomes: **PR**agmatic **I**nstitutional **S**urvey and bench**M**arking for Cancer Outcome Research

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Abstract

Background: Multi-centre precision oncology real world evidence (RWE) from hospital electronic health records requires a substantial long-term investment by hospitals to prepare their data and align on common Clinical Research processes and medical definitions. Based on previous experience running over 30 commercial oncology RWE projects over the last 5 years, we have developed a self-assessment framework to support hospitals to measure their digital maturity and better plan and coordinate those investments. From that framework, we developed PRISM for Cancer Outcomes: **PR**agmatic **I**nstitutional **S**urvey and bench**M**arking.

Objective: The objective of this work is to introduce PRISM for Cancer Outcomes, establish it as a valuable tool for self-assessment of the digital maturity of oncology hospitals and research networks and create an initial benchmarking cohort for future development.

Methods: PRISM consists of a 25 question semi-quantitative self-assessment survey over four digital maturity dimensions: 1. Precision oncology, 2. Clinical digital data, 3. Routine outcomes and 4. Information governance and delivery. These reflect the three main data types and critical enablers for precision oncology research from routine electronic health records (EHR).

Results: PRISM was piloted with 26 hospitals from 19 European countries from the OECI (Organisation of European Cancer Institutes, Europe's largest network of care quality focused cancer centres) and DIGICORE (Europe's largest network of cancer centres dedicated to international RWE) to create an initial benchmarking cohort. We found statistically significant differences in digital maturity, with Precision oncology being the most mature dimension, and Information governance and delivery the least mature.

Conclusion: PRISM is a light footprint benchmarking tool to support planning of large-scale real world research networks. It can be used to i) help an individual hospital identify areas most in need of investment and improvement, ii) help a network of hospitals identify sources of best practice and expertise, and iii) help research networks plan research. With further testing, policymakers could use PRISM to better plan digital investments around the Cancer Mission and European Digital Health Space.

Key words: Real World Data; Real World Evidence; Pragmatic Clinical Trials; Hospital Digital Maturity; Cancer Outcomes Research; Molecular Data; Survey.

1. Background

Large scale digital research consortia in tertiary hospitals focused on Real World Evidence (RWE) in specialty diseases face unique organisational challenges as they seek to plan for their digital research programmes. One of the most fundamental is to create a way of describing their digital maturity between institutions, as this is essential to good digital research planning. This is especially true in the era of Precision Medicine when assessments

of digital maturity need to cover much more than core Electronic Health Records (EHR). To scale research to multiple centres in precision oncology we need to assess availability of routine molecular information, clinical outcomes and operational and legal constraints on study design and delivery.

DIGICORE, the Digital Institute for Cancer Outcomes Research, was founded in 2020 to drive this digital agenda across Europe [1-2]. The purpose of DIGICORE is to improve cancer outcomes in Europe and accelerate innovation through digital research infrastructure development focused on creating digital interoperability between its members. It was formed from three research networks (Unicancer, Alleanza Contro il Cancro and IQVIA's specialist RWE delivery unit the Oncology Evidence Network - OEN) and in strategic partnership with the OECI. As DIGICORE has grown to 40 cancer centres from 17 counties our need for a common language on digital maturity has become acute.

The team running IQVIA oncology evidence network has extensive experience in the centre selection and delivery of multi-centre protocolised research in Europe, such as BMS I-O Optimise [3] and multiple regulatory grade external comparators to provide case matched controls to single arm trials [4-5]. Based on that experience, we developed a framework for discussing digital maturity with potential partner hospitals. The self-assessment framework has four dimensions: I) Precision oncology maturity to describe the state of routine molecular testing, ranked by its frequency and complexity, II) Clinical digital data to describe the maturity of treatment and observational data in a hospitals EHR, III) Pragmatic outcomes maturity to describe the availability of key outcome information in a hospital on its patients and IV) Information governance and delivery maturity to describe a hospitals legal and operational capacity to mobilise its EHR for advanced research that is not dependent on traditional study specific consent and manual retype. Based on this experience, we find three broad tiers of digital maturity that center can be at in their digital maturity journey: bronze, silver, and gold (Fig.1)

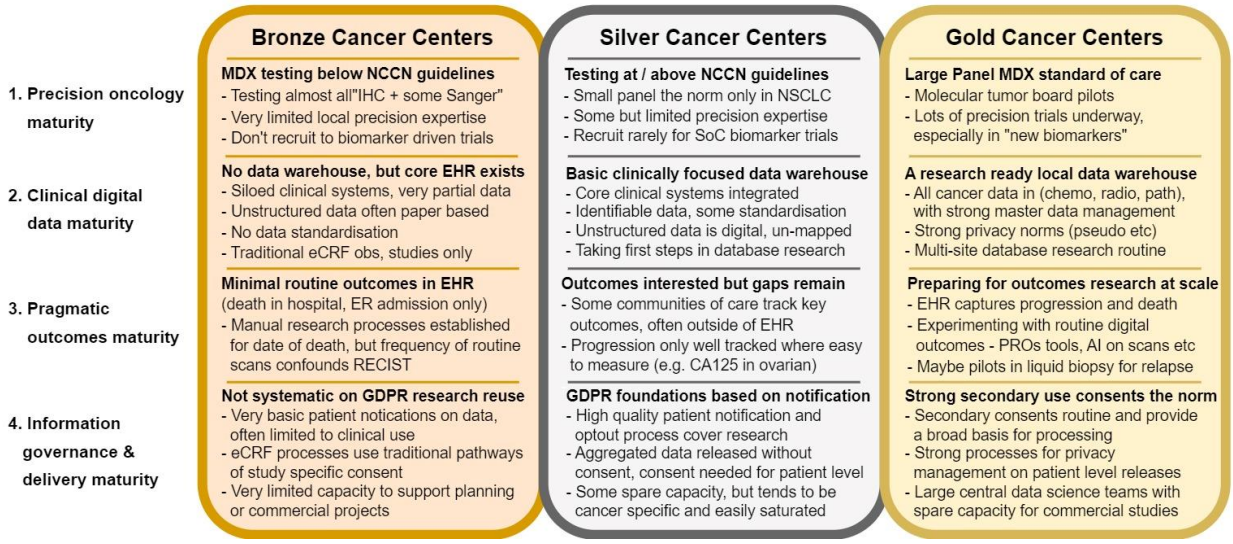

Fig.1: Digital maturity framework with bronze, silver and gold classification

2. Objectives

The Oncology Evidence Network (OEN) team historically used this framework in a three-step due diligence process to select research hospitals for commercial RWE including I)

literature reviews to identify hospitals that have used their EHR for cancer RWE studies, II) interviews with those hospitals staff to understand their interest in the research objectives and III) an intensive two week on-centre data and IT systems assessment to understand study feasibility in detail. Approximately 50 European centres have been through to step II of the due diligence process, and approximately 20 centres to step III since the OEN was founded.

However, whilst robust, the effort required to review a single hospital was not scalable; each individual hospital assessment would typically take one year of elapsed time and between three and six months of effort. Something lighter is needed for planning large digital networks. The Healthcare Information and Management Systems Society (HIMSS) maturity frameworks [6] are incomplete for research planning, as they describe the maturity of data integration for care delivery, not for research.

The OEN team questioned if a semi-quantitative self-assessment survey could codify their experience to create a simple tool for digital research maturity planning. This article presents the development of such a tool, and the results from an initial benchmarking survey run in partnership with the OECI and DIGICORE.

3. Methods

3.1 Survey instrument design

We developed the semi-quantitative survey in an iterative manner to get to a reliable instrument that balanced granularity against effort to complete with the following design principles: A) **Feasible:** with no more than 25 questions B) **Objective:** the semi-quantitative graduations from 1 to 5 should be as factual as possible and clearly defined to avoid subjectivity C) **Representative:** based on the team's prior experience a "3" should be typical for a hospital running outcome studies from EHR today, a "5" best known practice and a "1" a typical low digital maturity hospital, D) **Clear:** the text should be clear in international English for non-native speakers E) **Balanced**: both over the dimensions of digital maturity in the framework, and with a mixture of leading and lagging indicators F) **Informative**: the resulting benchmark captures the essence of the maturity of an individual institution for precision oncology RWE research and be useful to participating centres.

The first draft was tested with Leeds Cancer Centre in England and Frankfurt University Hospitals in Germany. The draft was refined based on feedback to create a document that could be completed by a hospital Data Manager or a similar role without supervision. The questionnaire had extensive instructions and a video briefing to help coach hospitals as to how to fill it in. The central team were also available to clarify questions or interpretation. The final instrument is available in the supplementary materials. Particular care was taken to objectively define each score on each dimension in clear, international English.

3.2 Sample recruitment

We chose to invite European cancer centres from three networks to the survey in second half of 2021 / H1 2022. At the time, this included the Organisation of European Cancer Institute (OECI), 21 members of DIGICORE and 7 cancer centres in IQVIA's networks. There is significant redundancy in these networks, and at the time of survey the list of hospitals invited was 106 unique hospitals and >98% correspondent to the OECI.

During the development of the OEN, we realised that many research-intensive European hospitals were conscious of weaknesses in their EHR data quality, creating a barrier to survey participation. To reduce this barrier, and to reduce the likelihood of positivity bias in the self-assessment, all hospitals were promised anonymity in the results. The results would only to be published in aggregate, unless otherwise agreed.

Participating hospital recruitment was coordinated in partnership with the relevant management teams of the OECI and DIGICORE in two waves. Wave 1 ran in September and October 2021, in preparation for DIGICORE's first membership Conference. Wave 2 ran March to June 2022 in preparation for a DIGICORE coordinated funding scheme to support hospital OMOP CDM conversions. This coordination of recruitment with both funding schemes and with the blessing of the relevant network coordinators likely explains the high penetration (26 of 106 centres) of the survey into the sample. The surveys take 1-2 days of a hospital project manager to identify the right experts and complete over a week or two. This is substantially lower effort than the intensive due diligence process it replaced.

The proposed analytic output would include a mapping of the entire network in statistically aggregated data, and a read-out for each hospital to benchmark itself against peers in private. A hospital was given an assessment on each of the four dimensions as the median of the scores in the relevant section of questions and then an overall digital maturity scores equal to median of the 4 sub-dimensions. All 25 questions are listed as part of Figure 2A. Community distributions were assessed on this overall digital maturity metric unless stated otherwise. Differences between these metrics were explored using Friedman test and paired Wilcoxon signed rank test. Finally, hospitals were asked to supply 2019 total new diagnostic volumes to allow the final visualisation.

4. Results

4.1 Network wide results

Survey completeness was high, with 21 out of 26 (80.7%) surveys with all question answered. A subset (5/26, 19.2%) had missing responses to one or two questions. Missing data was treated by assigning a score of zero (0) on the 1 to 5 scale.

We shared three visualisations of the hospitals that completed the survey while preserving centre-level anonymity. Fig.2A shows a visualisation of the community distribution displaying the median (red) and the two limits to the interquartile ranges (grey dashed lines) for each question across our community (N=26). Based on judgement, we allocated Gold to scores between 4.25 - 5, Silver 4.25 - 2.75, Bronze: less than 2.75.

Fig.2B demonstrates the community by major maturity dimension with a dot per hospital for that hospital's maturity score on that dimension.

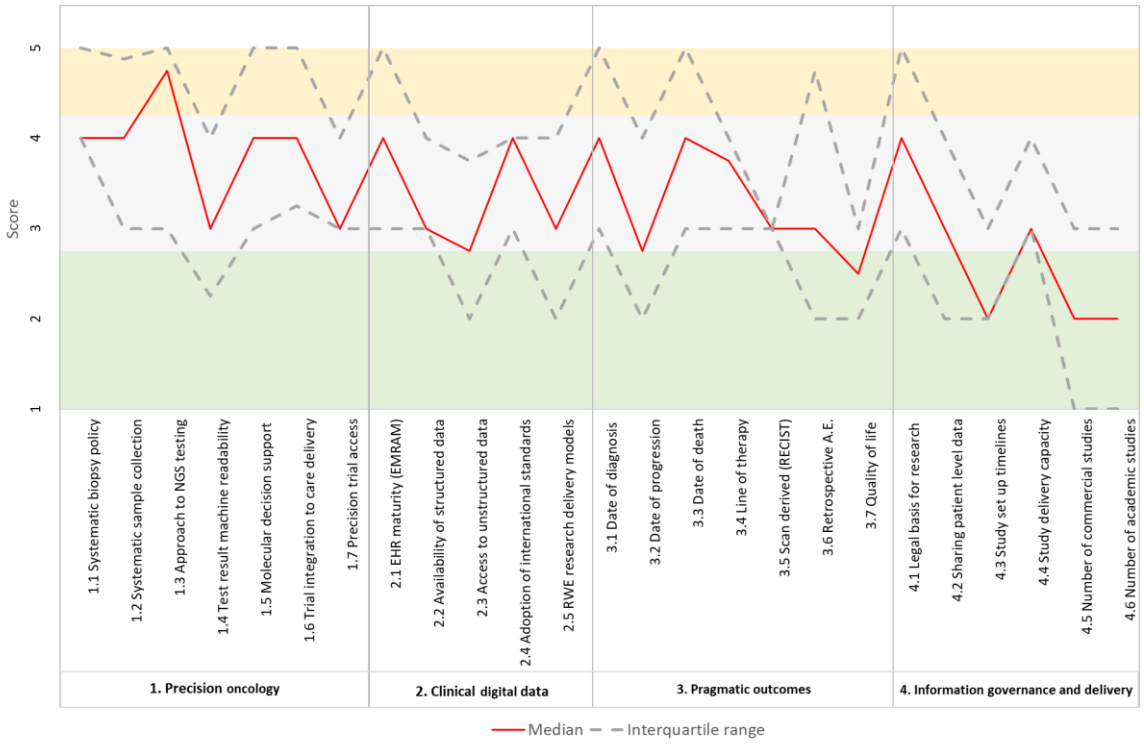

Fig.2A: Privacy conserving visualisation of the entire community by question showing Median and Interquartile ranges of responses to each question from the sample

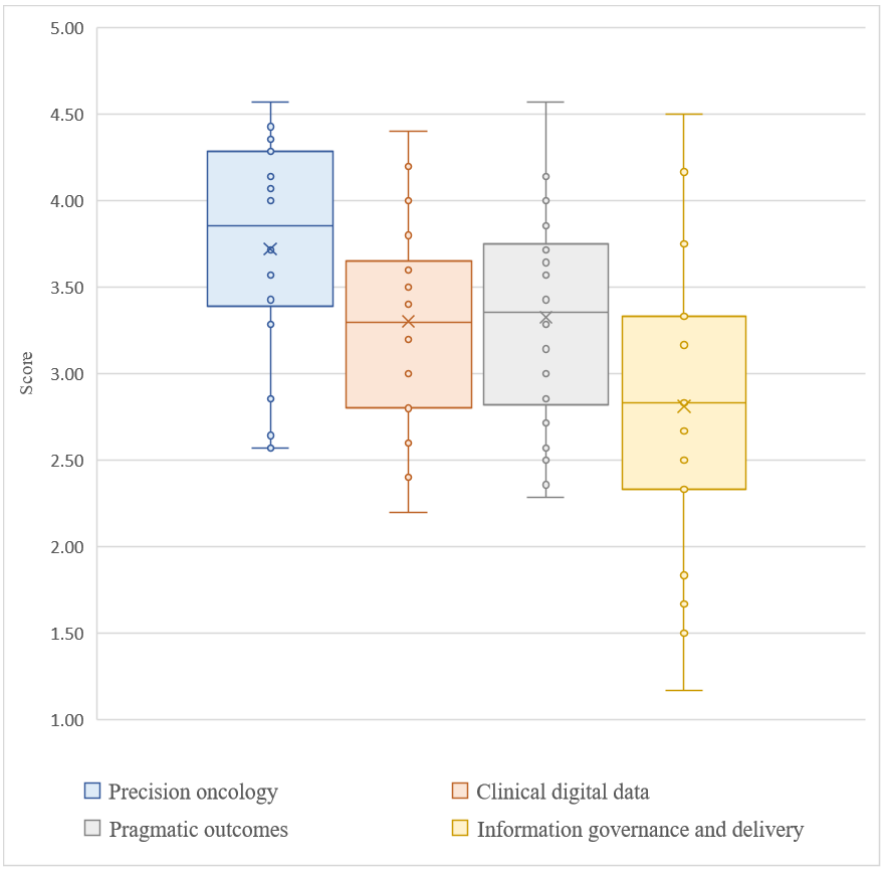

Fig.2B: Box plot of the four survey dimensions. The first dimension is precision oncology (blue, far left, average of survey questions Q1.1-1.7), the second dimension is clinical digital

data (orange, middle left Q2.1- Q2.5), third dimension is pragmatic outcomes (grey, middle right, Q3.1 to 3.7) and the last dimension is information governance and delivery (yellow, far right, Q4.1 to 4.6). The original survey used a 5-point score in which 1 represents the least mature option while 5 represents the most mature.

Table 1A shows the average and median scores for each of the 4 dimensions, Precision oncology dimension being the most mature, Information governance and delivery score the least mature, while Clinical digital data and Pragmatic outcomes showed similar (and intermediate) maturity. We used pairwise Wilcoxon sign-ranked tests to validate if these observed differences are statistically meaningful (table 1B). The results confirmed that only the difference between Precision oncology and Information governance and delivery ($p = 0.010$) is significant at $p = 0.05$. The rest of pairwise differences are not significant, however our expectation is that these differences will become clearer with a larger volume of data.

Overall score per dimension (n=26)	**Average score**	**Median Score**
1. Precision Oncology	3.72	3.86
2. Clinical Digital Data	3.30	3.30
3. Pragmatic Outcomes	3.33	3.36
4. Information governance and delivery	2.81	2.83

Table 1A: Average and median digital maturities in the sample by dimension

Dimension	2. Clinical digital data	3. Pragmatic outcomes	4. Information governance and delivery
1. Precision oncology	0.069	0.235	0.010
2. Clinical digital data	-	1.000	0.058
3. Pragmatic outcomes	-	-	0.208

Table 1B: Bonferroni-adjusted p values for pairwise Wilcoxon sign-ranked tests between the maturity dimensions (green, significant at $P<0.05$, red, not significant, grey not applicable)

4.2 Individual Centre Results

Individual results for 26 centres were shared benchmarking each centre's results (blue) against the median (red) in each of the 25 survey questions, the overall median score for each of the four dimensions and overall median score. A typical visualisation of an anonymous centre is shown below (Fig 3). All centres were classified using their median digital maturity score across the four dimensions. Given the commitment made to anonymity, we share here an illustrative unnamed example. Visualisations including the interquartile range (similar to Fig. 2A) were found to be visually confusing by centres.

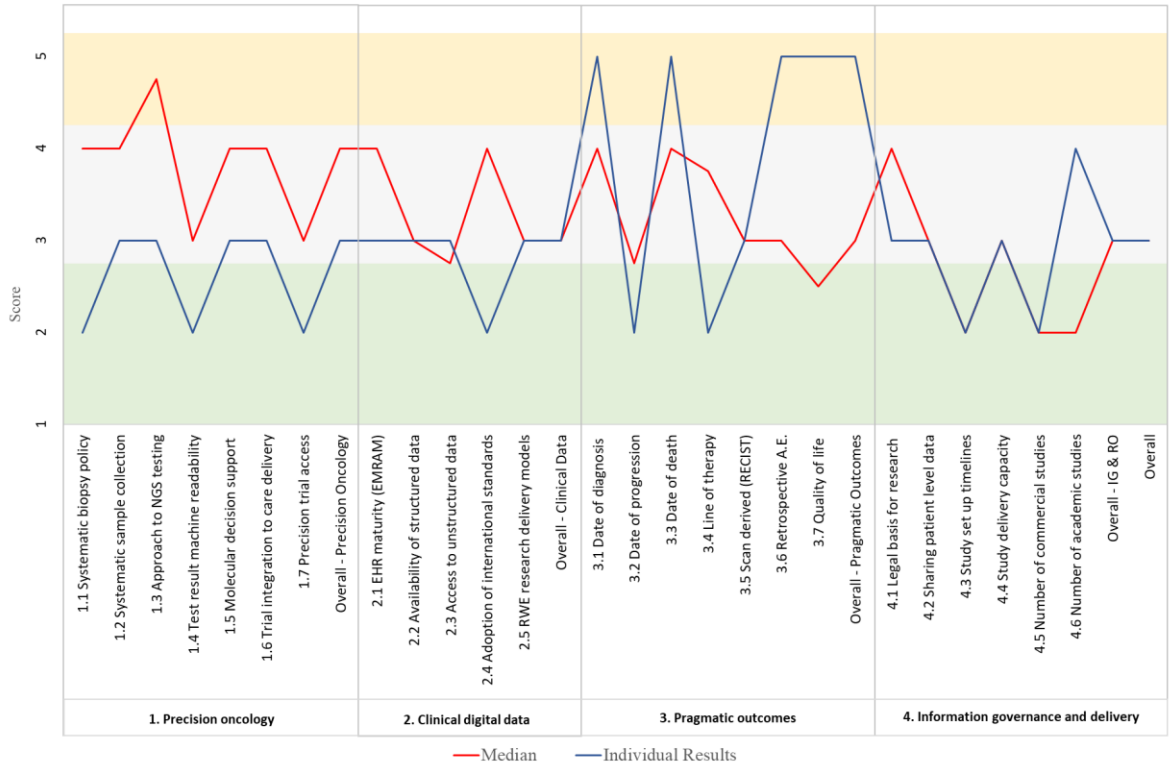

Fig.3: Anonymous example of the individual results shared back to the hospitals

Feedback from this and other hospitals was that the visualisations were both useful in promoting internal discussions on digital maturity, and the results in line with internal expert expectations. However, with only 26 hospitals in the sample we made no attempt to formally test the survey's utility or perceived accuracy.

4.3 Use for research planning

Fig.4 Shows a snapshot of the cancer digital maturity across the cohort surveyed by hospital. The X axis represents the grade of precision oncology maturity (section 1 of the survey) while the Y axis shows the outcome data maturity (section 3 of the survey). The colour of the bubbles represents the degree of clinical digital data maturity of each centre; top quartile (green), between interquartile range (amber) and bottom quartile (red). 19 Centres provided counts for annual patient diagnostics (Dx); the remaining centres were estimated using the average annual number of new cancer diagnostics across the 19 centres with data.

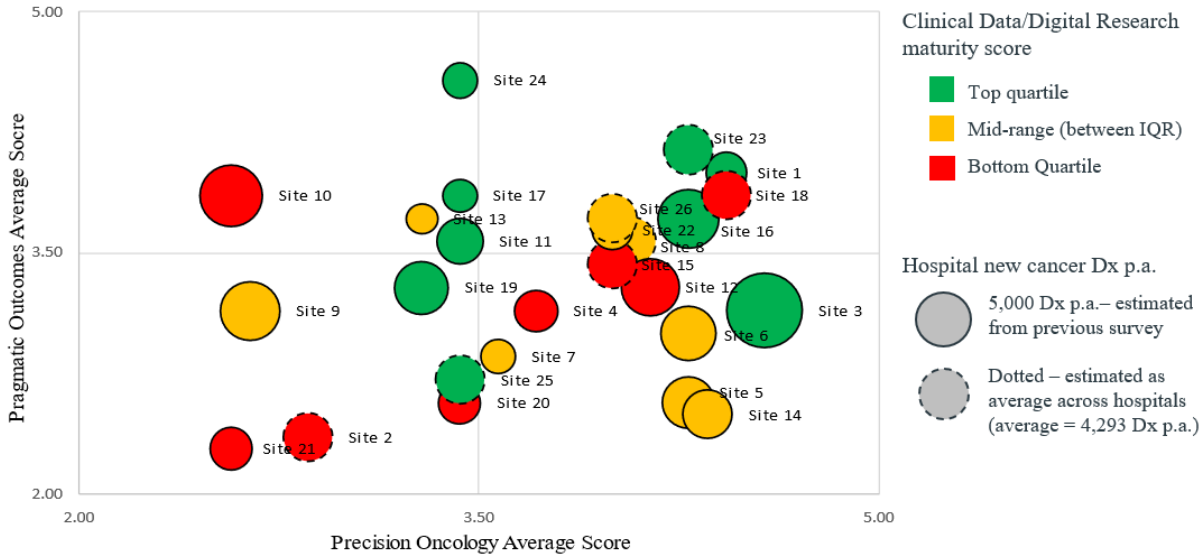

Fig.4: Cancer digital maturity snapshot

We are currently experimenting with how to use such visualisations in research planning. As an example, hospitals in the top right quadrant would make good partners for clinical biomarker validation research, having both good outcome and molecular data availability. Members of the bottom right quadrant have data suitable for biomarker driven trial recruitment, but not a broader range of real world research use cases. Site 24 has exceptional routine patient reported data and could be a potential bid coordinator for patient-reported outcomes (PRO) research calls.

5. **Discussion**

An initial benchmarking cohort for cancer outcomes was created utilizing PRISM semi-quantitative self-assessment survey on 26 hospitals from 19 European countries across OECI and DIGICORE. We find that academic hospitals participating are better on the management of precision oncology data than other aspects of digital research, perhaps reflecting academic investments in discovery science and precision trial recruitment.

The weakest area, even in top academic centres, is in information governance and delivery. Effectively, while hospitals may have data, they often don't have the legal basis and appropriate control processes to mobilise it towards research. If Europe is to mobilise its extensive health data to the public good, dedicated investment by policy makers in this is required. Europe will need targeted programmes to help weaker centres improve their data governance, not HORIZON-like programmes to invest in improving existing experts. The success of the Beating Cancer Plans [7], and key elements of the Cancer Mission [8] depend on this.

Measuring the digital maturity of a large cohort of hospitals is helping DIGICORE members in four ways.

Firstly, it identifies a *Direct Institutional Benchmark*, holding up a mirror to internal views on progress that each centre is making to digitize, and where to focus efforts to prompt internal management discussion and prioritise local digital investments. Secondly, it identifies *best practices at European level*, specifically institutions which are best practice in particular elements of digital research as *sources of expertise* to others, and from which DIGICORE's community of peer cancer centres can learn. Furthermore, it catalyses collaborative research, enabling collaborative digital research projects within DIGICORE to come together between *expert centres* to develop new clinical informatics solutions. This is especially useful for HORIZON grant planning, given most clinical informatic investments to date have been national, and so few European hospitals have well established international digital research peer networks. Finally, it *tracks digital progress*: the PRISM survey can be repeatedly taken to track the progress in digitization, for instance after digital infrastructure investments.

Limitations to the surveys include their self-assessment and self-reported nature, as well as their English Language basis. These were design compromises required to reduce assessment burden. We also suspect that the sample is biased towards research intensive and potentially more digitally interested hospitals. Supporting this is the observation that 33% of OECI accredited members participated, as opposed to 21% of the OECI membership overall. This accreditation process [9] tends to select for more research intensive and digitally mature members (Prof. Simon Oberst, accreditation lead, OECI personal communication). As a result, the results are not indicative of the overall maturity of European academic cancer centres, let alone non-academic cancer centres. Larger, more representative samples would be needed for PRISM to help input to either national or European digital policy planning, for instance on the European Health Data Space.

Finally, the sample was too small for it to be worth formally testing perceived survey accuracy or utility. The surveys and benchmarking are open to other European consortia to participate, so we envision this process to evolve and improve over time.

6. Conclusions

PRISM serves as a rationalised benchmarking instrument suitable for extensive hospital real world research networks. PRISM enables individual hospitals to identify areas that require investment and enhancement, it assists networks of hospitals in determining best practices and expertise, and aids research networks in their research planning. With additional validation, PRISM could be leveraged by policymakers to strategically plan digital investments in alignment with the Cancer Mission and the European Digital Health Space.

Clinical Relevance Statement

A simple 25 question self-assessment can capture the essence of hospital digital research maturity for outcomes research and digital care quality improvement. European policy makers need to invest to improve hospital data governance to support digital care quality.

Multiple choice questions

1. The PRISM survey was divided into four dimensions in order to assess the digital maturity of each centre. Which is the correct name for the four dimensions?

a. Precision oncology, Surgery data, Pragmatic outcomes, Information governance and delivery.
b. Precision oncology, Clinical digital data, Pragmatic outcomes, Information governance and delivery.
c. Oncology treatment data, Clinical digital data, Pragmatic outcomes, Information governance and delivery.
d. Precision oncology, Clinical digital data, Pragmatic outcomes, Privacy maturity.

Correct Answer: the correct answer is option b. The four-dimension used to evaluate the digital maturity are Precision oncology, Clinical digital data, Pragmatic outcomes, Information governance and delivery

2. This study showcased the multiple benefits and use cases for PRISM. Which one of the following options describes a beneficial use case for PRISM?
    a. Help an individual hospital identify areas most in need of investment and improvement.
    b. Help a network of hospitals identify sources of best practice and expertise.
    c. Help research networks plan their research.
    d. All of the above.

    Correct Answer: the correct answer is option d.

Acknowledgments

Conflict of Interest

None declared.

Protection of Human and Animal Subjects

Our study is exempted from Institutional review board.

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