IMI2 821513 – NEURONET

Efficiently Networking European Neurodegeneration Research

WP1 – Projects & Impact Analysis

# D1.4 First report on impact of IMI neurodegeneration portfolio


| | |
|---|---|
| **Lead contributor** | Jacoline Bouvy (2 – NICE) |
| **Other contributors** | Diana O'Rourke (2 – NICE) |
| | Pall Jonsson (2 – NICE) |
| | Carlos Diaz (1 – SYNAPSE) |
| | Nina Coll (1 – SYNAPSE) |
| | Angela Bradshaw (3 – AE) |
| | Jean Georges (3 – AE) |
| | Lennert Steukers (4 – JPNV) |
| | Manuela Rinaldi – 4 – JPNV) |
| | Laurent Pradier (8 – SANOFI) |
| | Katherine Fletcher (9 – Parkinson's UK) |

# Contents

# Document history

| Version | Date | Description |
|---|---|---|
| V1.0 | 27/07/2020 | First draft |
| V1.1 | 05/08/2020 | Comments |
| V1.2 | 21/08/2020 | Second draft |
| V1.3 | 01/09/2020 | Comments |
| V1.4 | 02/10/2020 | Third draft |
| V2.0 | 27/10/2020 | Final draft |
| V2.1 | 03/11/2020 | Comments |
| V3.0 | 10/11/2020 | Final version |

# Definitions and abbreviations

Partners of the NEURONET Consortium are referred to herein according to the following codes:

1. **SYNAPSE**: Synapse Research Management Partners SL
2. **NICE**: National Institute for Health and Care Excellence
3. **AE**: Alzheimer Europe
4. **JANSSEN**: Janssen Pharmaceutica NV
5. **LILLY**: Eli Lilly and Company Limited
6. **ROCHE**: F. Hoffman – La Roche AG
7. **TAKEDA**: Takeda Development Centre Europe LTD (*terminated partner*)
8. **SARD**: Sanofi-Aventis Recherche & Développement
9. **PUK**: Parkinson's Disease Society of the United Kingdom LBG
10. **TAKEDA AG**: Takeda Pharmaceuticals International AG

**Grant Agreement:** The agreement signed between the beneficiaries and the IMI JU for the undertaking of the NEURONET project.

**Project:** The sum of all activities carried out in the framework of the Grant Agreement.

**Work plan:** Schedule of tasks, deliverables, efforts, dates and responsibilities corresponding to the work to be carried out, as specified in Annex I to the Grant Agreement.

**Consortium:** The NEURONET Consortium, comprising the above-mentioned legal entities.

**Consortium Agreement:** Agreement concluded amongst NEURONET participants for the implementation of the Grant Agreement. Such an agreement shall not affect the parties' obligations to the Community and/or to one another arising from the Grant Agreement.

**IMI**: Innovative Medicines Initiative

**ND**: Neurodegenerative Disorders

**WP**: Work Package

# Abstract

Neurodegenerative diseases represent a global public health priority and despite high levels of research expenditure, a lack of effective therapeutic interventions remains. The Innovative Medicines Initiative (IMI) funds a number of European neurodegenerative disease projects aimed at addressing the key challenges in this disease area. Through research and development and collaborative partnerships, it is anticipated that the project portfolio will accelerate innovation and ultimately lead to the development and implementation of novel therapeutics. This deliverable aimed to assess the impact of the IMI neurodegeneration project portfolio both in terms of its capacity to innovate and the outputs that it has produced.

We used two approaches to assess the overall impact of the neurodegenerative disease project portfolio. Firstly, using network analysis, we analysed the extent to which the characteristics and structure of the project portfolio can facilitate innovation through enabling new knowledge and newly develop outputs to easily be shared among projects. Secondly, using the publications as a measure of output, we assessed collaborations between partner organisations on project publications. We also reviewed the publications to see how the portfolio is contributing to the delivery of key scientific priorities in the field of neurodegeneration. We complemented this view with the number of assets produced by the different projects as compiled in NEURONET.

Overall, our results show that EFPIA partners are the most connected to other partner organisations across the neurodegenerative disease project portfolio and therefore have the greatest potential for disseminating knowledge and ensuring that tools and methods are shared within organisations and between projects. However, whilst EFPIA partners have the greatest potential for sharing knowledge, when we analysed co-authorships on publications we found that a high proportion of publications were authored by single academic organisations or multiple collaborations between academic partners. This may be due to a lower incentive to publish for EFPIA partners as compared to academic organisations. Qualitative research is needed to understand if this lack of cross-partner collaboration on publications is inhibiting the effective dissemination and knowledge sharing across the whole network of IMI project organisations.

# 1 Introduction

The mission of IMI2 is to "*improve health by speeding up the development of, and patient access to, innovative medicines, particularly in areas where there is an unmet medical or social need*"[1]. Therefore, the ultimate impact that IMI projects can have is to enable the development, approval and access to effective and affordable medicines. There is an implicit assumption that spending on research and development (R&D) through the activities of the IMI neurodegeneration project portfolio might improve innovation in this disease area. Therefore, if we want to assess the impact of the IMI neurodegeneration project portfolio, we will need to identify :

(1) what factors are likely to facilitate pharmaceutical innovation in neurodegenerative diseases, and

(2) how is the IMI neurodegeneration project portfolio contributing to these factors

Innovation was famously defined as the process of '*creative destruction*' by economist Joseph Schumpeter. In practice, there are vast differences in the rate of pharmaceutical innovation seen in different diseases, as measured by the number of new drug approvals. The lack of newly approved drugs for dementia and other neurodegenerative disorders mean there will be certain factors that make innovation in the neurodegenerative diseases especially challenging. When looking at the impact of the neurodegeneration project portfolio, it is important to understand what these factors are, if we are to assess the possible impact the project portfolio could have in enabling patient access to innovative medicines.

# 2 Scope and framework

Technological innovation is defined as the function through which new technologies – including new drugs – are introduced within the economic system. The process of technological innovation includes recognising new technological possibilities, as well as organising the human and financial resources that are required to transform ideas into products or processes (R&D) (Scherer 2001). However, technological innovation sometimes can precede scientific knowledge: practical interventions have come about before there was a scientific understanding as to how they worked. In addition, technological advances play a key role in enabling scientific knowledge: microscopes, for example, are essential to enable much scientific research (Dosi, Llerena, Labini 2006). The most efficient way to facilitate innovation, however, is not well understood and is likely to be sector-specific.

In the context of a number of projects operating within the neurodegenerative diseases, it is important to take a project portfolio view, and analyse the impact of the portfolio as a whole, rather than at the project level. Networks, both within and between projects, enable the *exchange* of knowledge and resources between actors, which can help them to make new combinations that can lead to new innovations (van Rijnsoever et al 2015). As collaborations of multiple public and private partner organisations, IMI projects have the potential to enable such exchange of information, both of pre-

[1] https://www.imi.europa.eu/about-imi/mission-objectives

existing information as well as of *new* knowledge that is generated during the project period. However, the amount of information and knowledge that can be exchanged will depend on established connections between public and private partners, as well as contractual arrangements that allow for sharing of tools and knowledge.

Within projects and the networks that projects consist of, technological diversity is important, but both too little and too much diversity can be harmful to innovation: too little diversity can result in technological lock-in of a suboptimal alternative with superior alternatives remaining undiscovered, whereas too much diversity in a network can hinder the establishment of standards and routines that can contribute to the successful development of a technology. Although it is likely that some optimal level of diversity in a network for facilitating innovation exists, this level is unknown and therefore, impossible to identify. It is possible, however, to identify clear cases of a lack of diversity or an abundance of diversity in a network (van Rijnsoever et al 2015).

Van Rijnsoever et al (2015) present a framework for the analysis of a research project portfolio (in their case, for research projects funded in the Netherlands on sustainable energy) for assessing the influence of network position and the composition of innovation on the creation diversion of an emerging technology at a system level. They looked at the number of ties between project partners in different projects, the amount of clustering, the number of project partners, partner diversity, resource variety, sector diversity, and geographical distance. The majority of this information has been collected by Neuronet, and therefore can be used to explore the IMI neurodegeneration portfolio through network analysis. This will provide insight into the deeper underlying structure of the project portfolio and how this structure might facilitate or hinder innovation.

In order to perform a comprehensive impact analysis of the IMI neurodegeneration project portfolio, it will be crucial to not only assess the structure and characteristics of the project portfolio, but also to assess what the outputs of the project portfolio have been – what tools and knowledge has been produced – and to what extent these help facilitate innovation in neurodegenerative diseases. In 2019, the EU Joint Programme on Neurodegenerative Diseases (JPND) published an update of its Research and Innovation Strategy (JPND 2019). This document provides a 'common framework for future investment that addresses how countries can effectively improve prevention, diagnosis, treatment and patient care for neurodegenerative diseases' (JPND 2019). The framework presents the following **scientific priorities** for future research:

- The origins and progression of neurodegenerative disease
- Disease mechanisms and models
- Diagnosis, prognosis and disease definitions
- Developing therapies, preventive strategies and interventions
- Health and social care

JPND aims to progress these scientific priorities through the following **enabling activities**:

- Building supportive infrastructure and platforms
- Partnering with industry and fostering innovation
- Working with regulatory organisations to integrate patient needs

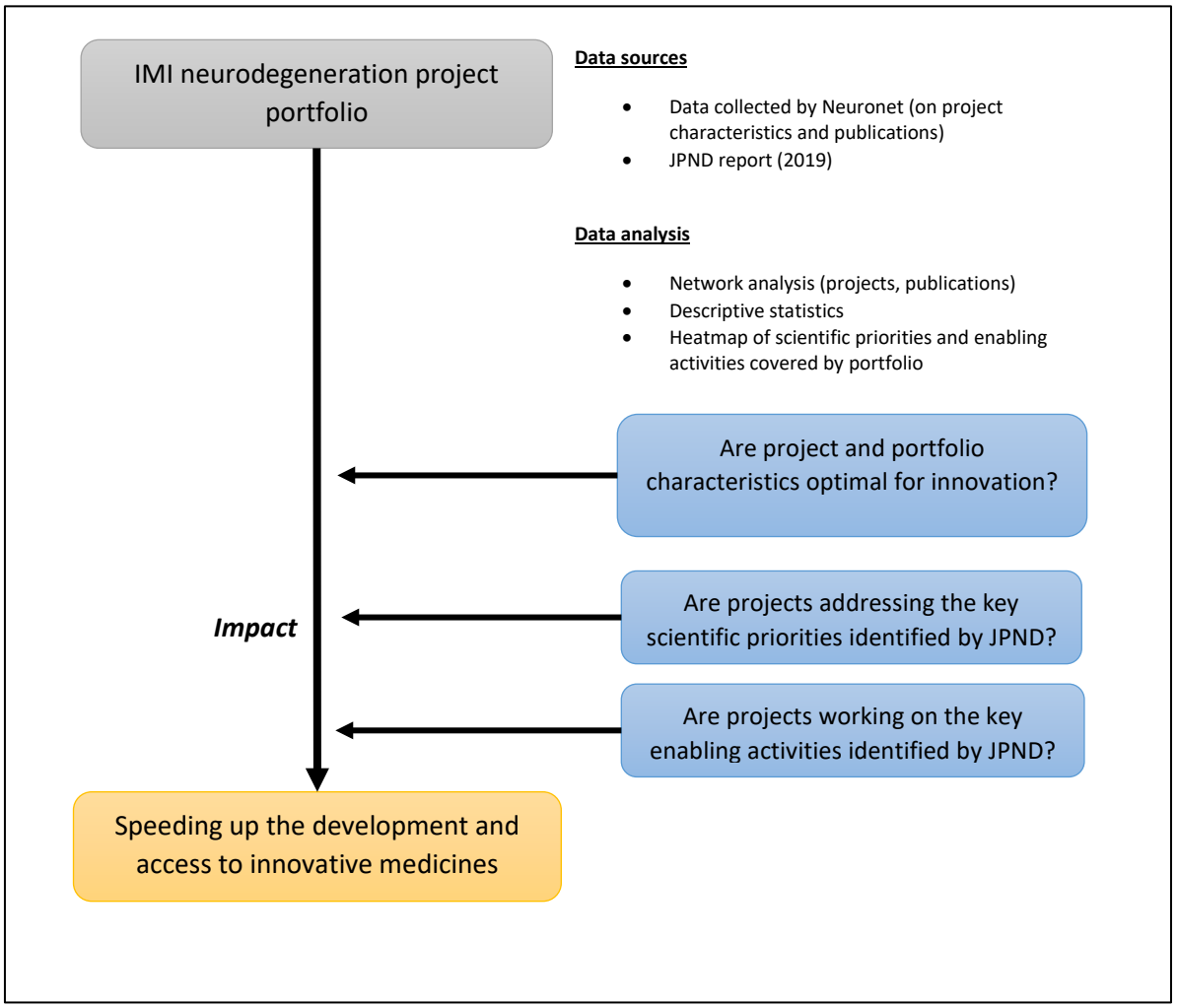
- Establishing international partnerships to link up global research efforts in neurodegenerative disease
- Building capacity through networks across and between disciplines and researchers
- Education and training to embed a research culture across the health, social and palliative care sectors
- Strengthening the connection to policy makers
- Ensuring effective communication and outreach with a wide range of sectors and stakeholders

Due to the more restrictive focus of the IMI ND portfolio on medicines, not all of these priorities and enabling activities are of the most relevance to our analysis. Notwithstanding, the JPND report provides a useful framework that identifies the key scientific priorities in neurodegenerative disease and the key enabling activities that are most likely to result in impact of the disease portfolio.

The aim of this deliverable was to assess the impact of the neurodegenerative diseases project portfolio. In this first version of the impact analysis, we have used publications and assets (as identified by Neuronet) as quantitative measures of research output although we recognise that publications represent only one aspect of project output. In the next version of the impact analysis (D1.7, due in month 36) we aim to broaden the scope to include an assessment of the wider impact of projects and their results.

# 3 Methods

Schematically, the impact analysis looks as follows:




The IMI neurodegeneration project portfolio consists of a number of completed and ongoing projects. Several of the projects are still ongoing or have only just been initiated. As it is difficult to determine the impact of outputs that are still in development and not yet completed, some part of the impact analysis will focus on all projects that are part of the portfolio, whereas other parts will only encompass the projects that have completed project activity before the 31st October 2020.

## 3.1 Approach

### 3.1.1 Project analysis

We analysed the 18 projects that are currently part of the IMI neurodegeneration portfolio. We collected the following information on each project:

- Project partner organisations
  - organisation type (Academic, EFPIA, Regulatory Agency, HTA body, patient/carer organisation, Small and medium-sized enterprises (SMEs), research funder, contract management organisation (CMO), other) and country
- Project assets (see Neuronet deliverable D1.2 Integrated programme Analysis v1 for details)
  - Number of assets

We used network analysis to characterise the IMI neurodegeneration portfolio. In the network, every unique project organisation represents a node with the connections between the nodes (edges) defined by organisations being part of one or more IMI projects in the portfolio. Edges were weighted to represent the number of projects that connect individual partners. This way, we identified clustering of key organisations and to make apparent how and to what extent knowledge between projects might be shared and disseminated by calculating measures of centralty, including the 'degree' and 'betweenness' of all the network nodes. The degree gives the number of ties that one organisation has to all other organisations in the network. For organisations that participate in 1 project only, the degree will be equal to the number of organisations in that project, minus 1. Betweenness represents the number of times a node (representing an organisation) is present in the shortest path between 2 nodes in the network. Calculating the betweenness of each organisation will provide insight into the key organisations in the network.

We used Rstudio and the igraph package for the network analysis and for creating the network visualisations. We used Microsoft Excel for the other analyses.

### 3.1.2 Publications co-authorship analysis

We only included the 8 projects that have already finished or are about to finish their activity (cut-off date 31/10/2020) in the publications analysis, as it is likely that projects that are still ongoing will not have published all or the majority of their outputs. The projects included were:

- ADAPTED
- AETIONOMY
- EMIF
- EPAD
- EQIPD
- MOPEAD
- PRISM
- ROADMAP

We collected the following information on the project publications:

- Publications (identified through project websites)
    - Title, Digital Object Identifier (DOI), first author, first author organisation, organisations of all co-authors on the publication

Where multiple authors were reported for the same organisation, the organisation was recorded just once. Authors from organisations that are not partners in the IMI project were recorded as 'non-IMI partner'. Where multiple authors were reported for different non-IMI organisations, this was recorded in just the first instance. This methodology is in line with the methodology used by IMI for its annual bibliographical analysis of all IMI projects[2].

First, we excluded duplicate publications. Then, for each publication, we calculated the total number of organisations from the project that were listed as a co-author on the publication. At the project level we calculated the number of publications per project; the number and percentage of project

[2] Bibliometric analysis of IMI ongoing projects: 10th Report September 2019 - https://www.imi.europa.eu/sites/default/files/uploads/documents/reference-documents/IMI_Bibliometrics_Report_2019_v4%20FINAL.pdf

organisations on at least 1 publication; the number and mean number of publications per organisation; and the percentage of all project publications each organisation was listed on. Furthermore, we assessed 'collaborativeness' by reporting the mean number of organisations that were listed as co-authors across all project publications, as well as analysing the mix of organisation types listed as co-authors. We also analysed the number and percentage of project publications where at least 1 non-IMI partner was listed as a co-author. We performed a network analysis to further characterise the collaborations between partner organisations in the co-authorship of project publications. We included all publications with at least 2 partner organisations listed as co-authors and all organisations that contributed to at least 1 of these publications in the analysis.

We calculated the 'degree centrality' for all the organisations included in the analysis, which corresponds to the number of other organisations in the network they were connected through. As we only included publications with multiple partner organisations listed, the minimum number of connections 1 organisation could have to another organisation was 1 (for example, if they published 1 paper where 1 other organisation was also listed as a co-author). The degree centrality gives an indication of how collaborative organisations are, as it indicates how many other organisations within their projects they have published with.

| | |
|---|---|
| **Theme One** The origins and progression of neurodegenerative disease | • The causes and progression of ND and the factors that affect risk and resilience.<br>• Understanding of disease phenotypes.<br>• New genetic, epigenetic, environmental and social modulators.<br>• The role of ageing and the relationship to ND development and resilience. |
| **Theme Two** Disease mechanisms & models | • Underlying disease mechanisms to inform new diagnostic and therapeutic approaches.<br>• Novel and improved existing animal and cellular models of ND.<br>• Reverse translation from ND patients to develop more predictive models and to determine the role of new pathways in ND pathogenesis. |
| **Theme Three** Diagnosis, prognosis & disease definitions | • New or improved diagnostic tools.<br>• Identification of novel biomarkers.<br>• Standardisation and harmonisation across tools and assessments. |
| **Theme Four** Developing therapies, preventive strategies & interventions | • Preventive strategies and interventions to reduce the risk of developing ND and promote the capacity of the brain to resist ND.<br>• Translation of basic research findings to clinical benefit.<br>• Development of regenerative strategies and novel systems for targeted drug delivery. |
| **Theme Five** Health & social care | • Understanding the factors that contribute to social inclusion, civic participation, dignity, health-related quality of life and wellbeing.<br>• Validation of research findings in real world settings, taking account of cost-effectiveness and ethical issues.<br>• Assisted living technologies<br>• Palliative and end-of-life care. |

**Figure 1.** Framework for scientific priorities in neurodegenerative diseases

### 3.1.3 Publication qualitative analysis of framework

We developed a framework for scientific priorities in neurodegenerative diseases informed by the JPND Research and Innovation Framework and the IMI Scientific Research Agenda (see figure 1). We reviewed all publications against the framework to assess the priorities they addressed. Firstly, we excluded duplicate publications and, for this analysis, we also excluded all publications that did not report new knowledge generated within the project (review articles, study protocols, and editorials). The abstracts (and full papers where available) of the publications were then assessed and themed under 1 or more of the 5 key scientific priorities. We then further categorised the publications using more detailed sub-headings. Where applicable, multiple categories were selected.

Publications which did not meet any of the scientific priority themes in the framework were categorised, where applicable, into 1 or more of the 8 enabling activities set out in the JPND report.

# 4 Results

## 4.1 Project analysis

### 4.1.1 Project characteristics

The project portfolio analysed consists of 18 projects in total, with 455 partners and a total funding budget of €386 million (Table 1). There are 239 unique partner organisations among the 18 projects. Sixty-four percent (N=152) of these organisations only participate in a single project, but 87 organisations take part in multiple IMI projects. The average number of projects an organisation is involved in is 1.9. However, the average number of projects that three types of organisations participate in, differs: Academic organisations participate in 1.7 projects on average whereas EFPIA companies participate in 4.0 projects on average, and SMEs participate in an average of 1.3 projects. This can be expected since the pool of EFPIA members is much smaller than for academic organisations.

| Project | Start | End | Partner organisations (N) | Funding |
|---|---|---|---|---|
| ROADMAP | 01/11/2016 | 31/10/2018 | 26 | € 8,210,381 |
| AETIONOMY | 01/01/2014 | 31/12/2018 | 18 | € 17,812,216 |
| ADAPTED | 01/10/2016 | 30/09/2020 | 13 | € 6,796,740 |
| EMIF | 01/10/2013 | 30/06/2018 | 60 | € 55,784,311 |
| EPAD | 01/01/2015 | 31/10/2020 | 39 | € 59,903,036 |
| EQIPD | 01/10/2017 | 30/09/2020 | 29 | € 9,360,692 |
| MOPEAD | 01/10/2016 | 31/12/2019 | 15 | € 4,581,968 |
| PRISM | 01/04/2016 | 30/09/2019 | 23 | € 16,195,875 |
| AMYPAD | 01/10/2016 | 30/09/2021 | 15 | € 27,329,288 |
| IDEA-FAST | 01/11/2019 | 30/04/2025 | 51 | € 40,922,059 |
| IMPRIND | 01/03/2017 | 31/01/2021 | 18 | € 11,363,398 |
| Mobilise-D | 01/04/2019 | 31/03/2024 | 36 | € 49,361,564 |
| PD-MIND | 01/05/2019 | 30/04/2022 | 10 | € 2,131,609 |

| | | | | |
|---|---|---|---|---|
| PD-mitoQUANT | 01/02/2019 | 31/01/2022 | 14 | € 6,882,315 |
| PHAGO | 01/11/2016 | 31/10/2021 | 20 | € 18,088,176 |
| RADAR-AD | 01/01/2019 | 30/06/2022 | 16 | € 7,640,145 |
| RADAR-CNS | 01/04/2016 | 31/03/2021 | 25 | € 25,712,110 |
| IM2PACT | 01/01/2019 | 31/12/2023 | 27 | € 17,410,136 |

**Table 1:** Project characteristics

| Partner type | N |
|---|---|
| Academic | 135 |
| EFPIA | 31 |
| Regulatory Agency | 1 |
| Patient/carers organisation | 7 |
| SME | 53 |
| Research Funder | 1 |
| HTA body | 1 |
| CRO | 1 |
| other | 9 |

**Table 2:** Partner types (N=239)

### 4.1.2 Project network analysis

#### *4.1.2.1 Partner organisations analysis*

Figure 2 represents the network of partner organisations of the 18 projects (N=239). The colours of the connections between the projects represent the weight of the connection. An orange connection means that 2 organisations are connected through participation in a single project, which represents the majority of the connections between organisations in the network, as there are 152 organisations that only participate in a single project. However, there are 87 partners who participate in multiple projects and the connections between these partners are indicated by different colours in Figure 2.

There are 18 projects that are part of the IMI neurodegeneration portfolio. The highest number of projects a single organisation is part of is 13 projects (N=1; Janssen Pharmaceuticals (Belgium)). The maximum connection weight in the network is 7, which means that at most, 2 organisations are both participating in the same 7 IMI projects. The minimum observed number of connections per organisation is 9, which means that every organisation in the network is connected to at least 9 other organisations. The maximum number of connections is 197 (Janssen Pharmaceuticals), which means that Janssen Pharmaceuticals is connected to 197 out of 239 organisations in the IMI project portfolio.

We calculated the betweenness for all organisations in the network, with the betweenness visualised in Figure 2, where the size of each node reflects the betweenness of the organisation. In this visualisation, there are a relatively small number of organisations that are the key nodes in the network. The top 20 organisations in the network are listed in table 3. Janssen Pharmaceuticals is the organisation with the highest betweenness centrality in the network. This is due to the large number of projects (13 out of 18) in which it participates. None of the other organisations in the top 20 of key nodes participate in more than 9 projects.

Further analysis shows that the 80% (N=16) of the top 20 nodes in the network participate in EPAD and 60% (N=12) in EMIF. EPAD is the third largest project in the portfolio in terms of number of partners and the largest project in terms of project funding, whilst EMIF has the highest number of project partners and is the second largest in terms of project funding. Conversely, only 2 of the top 20 organisations participate in both PD-MIND and PD-Mitoquant, 2 of the smallest projects in the

portfolio in terms of both number of partners and funding. For the majority of projects (N=17/18), the project leader and/or project coordinator is represented in the top 20 nodes, with the exception being PD-Mitoquant.

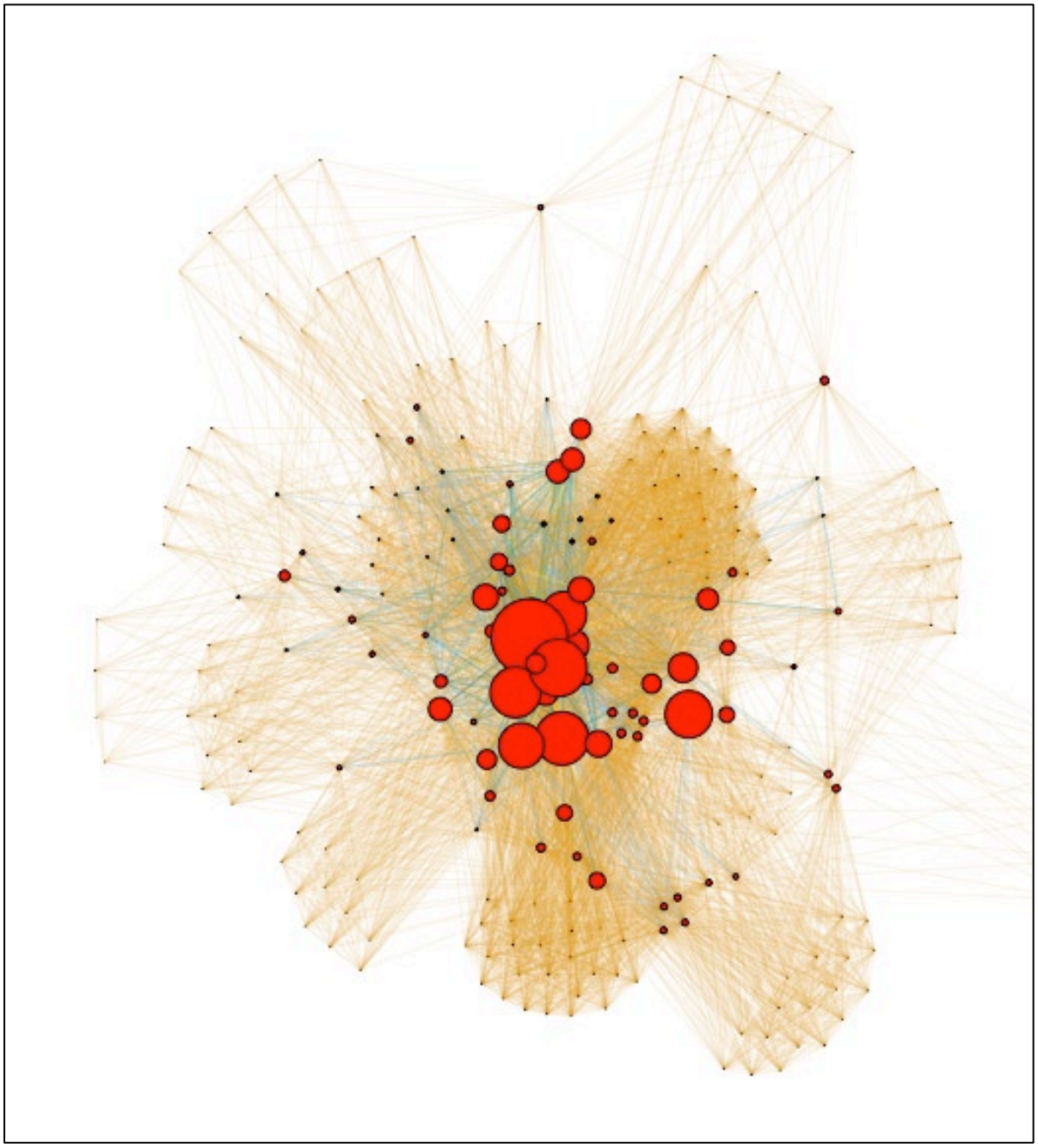


**Figure 2:** IMI neurodegeneration network of project partners (N=239). The size of each node reflects the 'betweenness' of the organisation. The colour of the connections represents the number of projects which connect individual organisations. Orange connections = 2 organisations are connected through participation in a single project; Blue connections = 2 organisations are connected through multiple projects.

The number of EFPIA companies in the top 20 nodes is higher than the proportion of EPFIA companies that are part of the entire portfolio: EFPIA companies represent 13 percent of all organisations in the network (N=30), yet 65 percent of the top 20 organisations in the network are EFPIA companies. Conversely, academic organisations comprise 56 percent of the network (N=128), yet only 30 percent

of the top 20 organisations are academic organisations. Five of 6 (Erasmus, VUMC, Karolinksa Institutet, Kings College London and University of Cambridge) of these academic organisations are in the top 8 academic organisations in terms of the number of projects participated in, and 2 (Erasmus and VUMC) in the top 10 overall. All of these academic organisations participate in EMIF, the project with the highest number of partners in the portfolio, and 4 of 5 organisations also participate in EPAD.

There are 51 SMEs that form part of the network. However, 80% of SMEs only participate in a single IMI project in the network in line with the clear strategic focus for such small organisations. On average, SMEs participate in 1.3 IMI projects, compared to 4.0 projects per EFPIA company and 1.7 per academic organisation.

| Organisation | Type | Projects | Betweenness | Degree |
|---|---|---|---|---|
| Janssen Pharmaceutica | EFPIA | 13 | 1498 | 197 |
| UCB Biopharma | EFPIA | 7 | 1125 | 165 |
| Pfizer | EFPIA | 7 | 1048 | 177 |
| Novartis | EFPIA | 9 | 995 | 142 |
| AstraZeneca | EFPIA | 5 | 929 | 108 |
| Eli Lilly | EFPIA | 8 | 895 | 133 |
| Sanofi Aventis | EFPIA | 7 | 890 | 150 |
| Erasmus Medical Center | Academic | 7 | 693 | 149 |
| Biogen | EFPIA | 5 | 615 | 117 |
| Merck Sharp Dohme | EFPIA | 4 | 576 | 126 |
| Takeda | EFPIA | 6 | 519 | 130 |
| H Lundbeck | EFPIA | 7 | 510 | 109 |
| F Hoffmann La Roche | EFPIA | 7 | 506 | 152 |
| Stichting VUMC | Academic | 7 | 495 | 131 |
| Abbvie | EFPIA | 5 | 457 | 100 |
| Karolinska Institutet | Academic | 6 | 449 | 110 |
| Alzheimer Europe | patient/carer organisation | 7 | 448 | 116 |
| Kings College London | Academic | 5 | 420 | 101 |
| Vib Center for Brain & Disease Research | Academic | 3 | 393 | 83 |
| University Of Cambridge | Academic | 5 | 389 | 132 |

**Table 3:** Key nodes in the IMI neurodegeneration project portfolio (as defined by betweenness centrality)

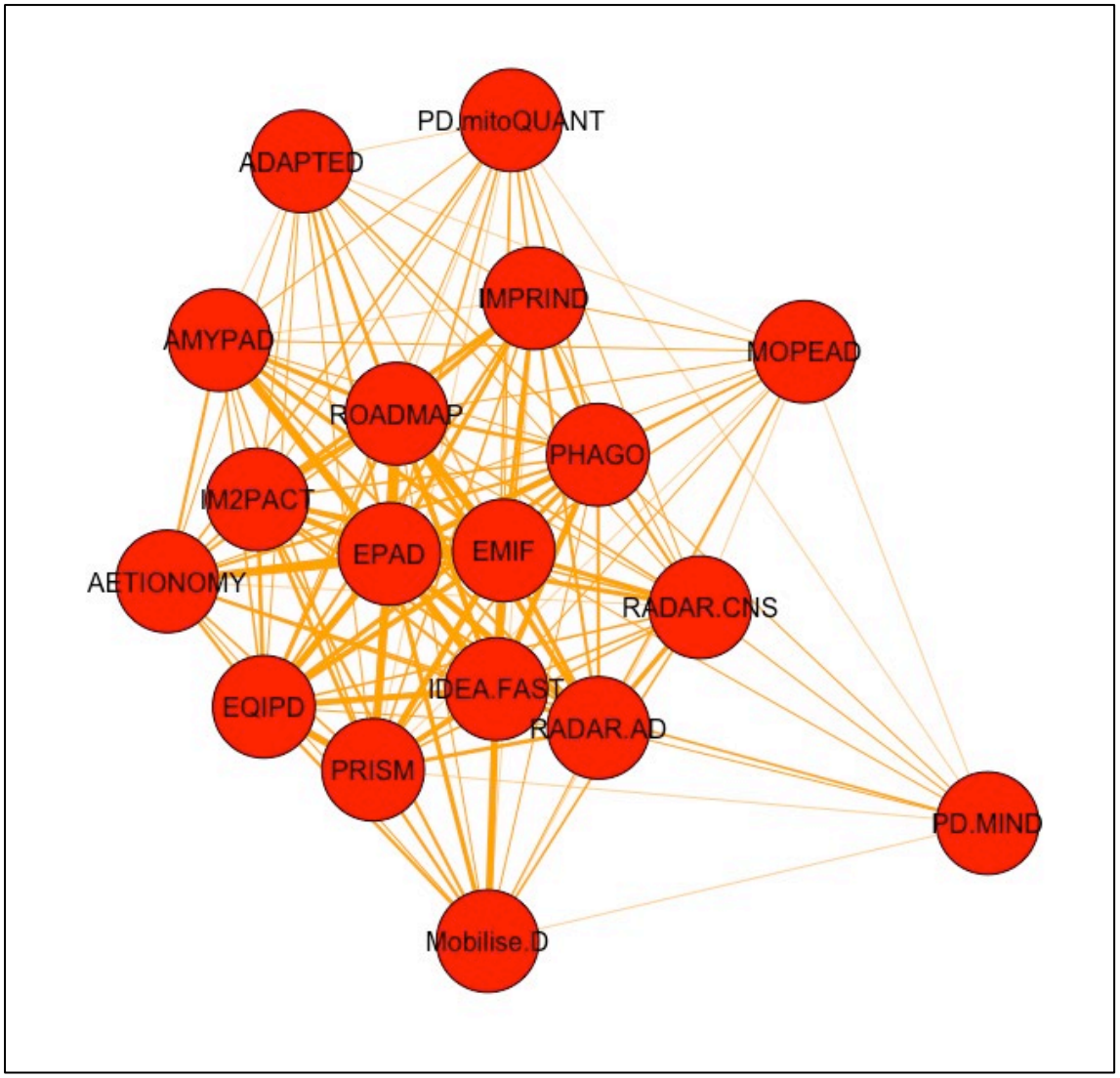



**Figure 3:** IMI neurodegeneration network of projects and the number of organisations shared between projects

#### *4.1.2.2 Project level analysis*

We also analysed the characteristics of the network at the level of individual IMI projects. In figure 3, the network of IMI projects that form the IMI neurodegeneration portfolio is visualised, where each node represents an IMI project. The connections between the projects represent the number of organisations that participate in both projects. Not all projects share partner organisations. For example, PD MIND is only connected to 9 other IMI projects in the portfolio. This is in part due to the size of the project, as it only consists of 10 partner organisations in total. All other projects are connected to 14, 15, or all other IMI projects in the portfolio. The width of the connections between projects indicates the number of organisations the projects share.

## 4.2 Publication analysis

### 4.2.1 Publication characteristics

There were 232 publications and 49 different assets across the 8 IMI projects included in the analysis as of 28/04/2020. The number of publications per project varied from 1 (MOPEAD) to 115 (EMIF) (table

4) and assets ranged from 2 (MOPEAD) to 11 (EMIF and EPAD)[3]. Although MOPEAD had only produced 1 publication, it had the highest proportion of partner organisations listed as co-authors (12/18, 80%). For the remaining projects, the proportion of partner organisations listed on at least 1 publication varied from 46% ((18/38) EPAD) to 78% ((14/18) AETIONOMY). However, with the exception of EPAD, in most projects the majority of partner organisations contributed to at least 1 publication.

| Project | Publications (N) | Project assets (N) | Project partners (N) | Partners on ≥1 publication (%) |
|---|---|---|---|---|
| ADAPTED | 7 | 5 | 13 | 77% |
| AETIONOMY | 39 | 8 | 18 | 78% |
| EMIF | 115 | 11 | 60 | 70% |
| EPAD | 20 | 11 | 39 | 46% |
| EQIPD | 23 | 6 | 29 | 62% |
| MOPEAD | 1 | 2 | 15 | 80% |
| PRISM | 17 | | 23 | 74% |
| ROADMAP | 10 | 6 | 16 | 73% |

**Table 4:** Project level summary

Interestingly, the number of assets does not apparently correlate at all with the number of publications. This can be expected as a number of assets may not be the object of publications (e.g. due to publication bias, or to protect IP), and, conversely, many publications report on partial results and general progress in knowledge without that necessarily constituting an asset.

EMIF had the highest mean number of publications per partner organisation (5.2, s.d=7.7) but also the highest variance with the number of publications per partner (ranging from 0 to 35). With the exception of MOPEAD which only has 1 project publication in total, EPAD had the lowest mean number of publications per partner (1.8, s.d=2.8, range 0-11) (figure 4).

The number and percentage of publications on which a partner organisation was listed as a co-author varied. The highest number of publications for a single organisation was 48 publications that were co-authored by Stichting VUMC across 3 IMI projects, which is a notable achievement given that the second highest number of publications co-authored by a single organisation is 32 publications by Janssen Pharmaceutica, but they participate in 6 IMI projects in total. However, 10 publications by Stichting VUMC did not include any other partner organisation among the co-authors. For Janssen Pharmaceutica, only 3 of 32 publications did not list any other project partners among the co-authors.

Further analysis of the 32 publications co-authored by Janssen Pharmaceutica revealed that they were the first author on 2 publications (EMIF and EQiPD), the sole author on 1 publication (EQiPD) and the last author on 4 publications (EQiPD (N=3) and PRISM (N=1)). On 2 of these projects, Janssen were the 'Project Leader' (EMIF and EQIPD). In contrast, of the 48 publications co-authored by Stichting VUMC, they were the first and last author on 18 publications (of which 6 publications were co-authored by multiple researchers from the same organisation), the first author on 1 and last author on 5

[3] The process of identifying assets is dynamic and a continuing activity. The numbers considered here are correspond to the initial asset identification as described in deliverable D1.2.

publications. Unlike Janssen, Stichting VUMC were not officially the project leader on any of the projects in which they participate[4].

Out of 142 organisations across the 8 projects, 47 organisations did not contribute to any of the project's publications. The majority of these organisations were academic organisations (N=16), SMEs (N=18), and EFPIA companies (N=8). This means that across all organisations in the 8 projects, 13% of the academic organisations, 33% of the SMEs, and 27% of the EFPIA companies did not contribute to any publications[5]. The vast majority of these organisations (N=42) only participated in 1 IMI project and only 1 organisation, Concentris (a research management company) participated in 3 projects. 10 of the organisations were work package leads/co-leads on 1 of the projects in which they participated, of which 5 were academic organisations and 3 were SMEs.

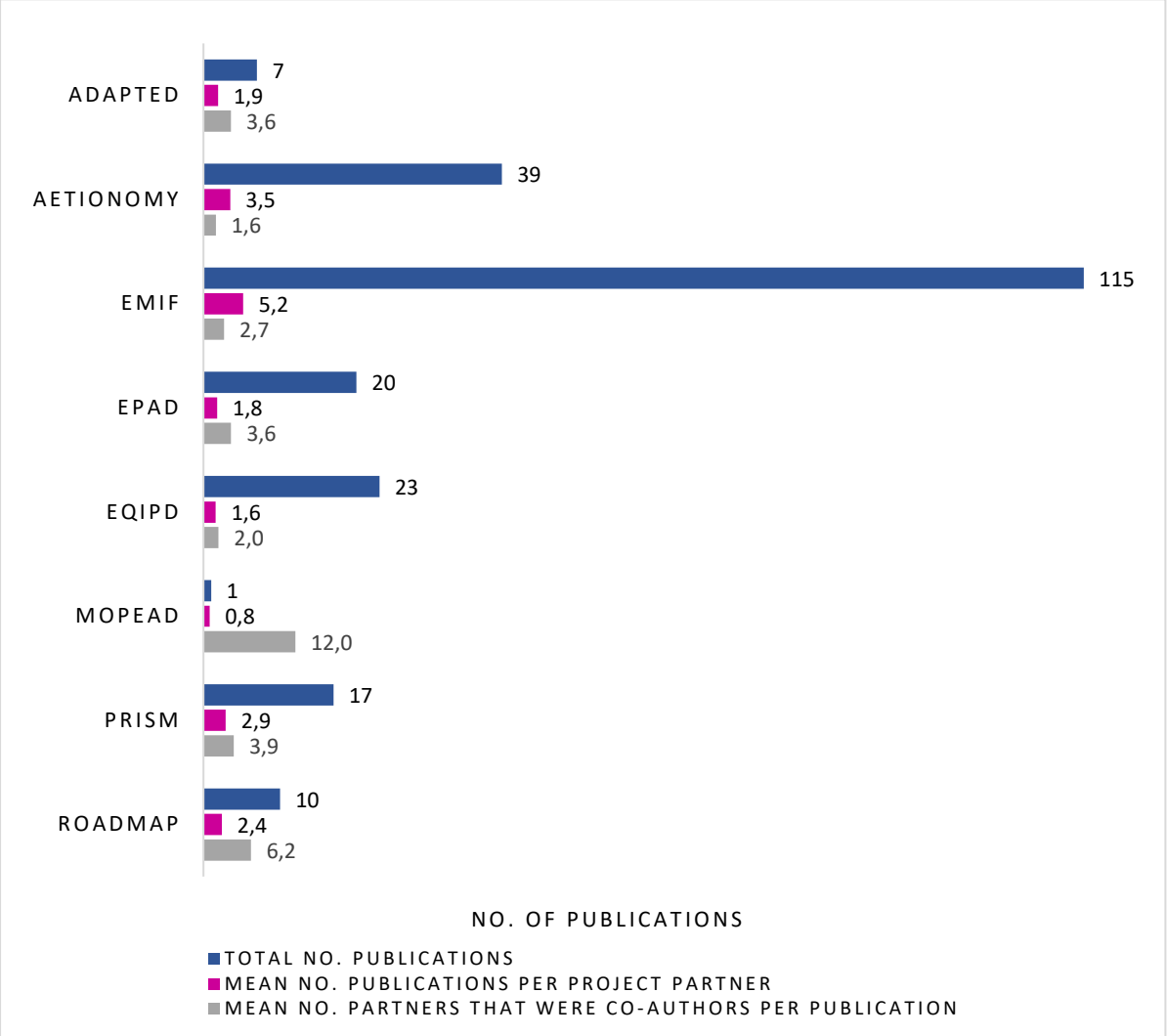



**Figure 4:** Project level publication analysis

Across all 232 publications, the number of partner organisations that were listed as a co-author on a publication ranged from 1 to 13, with a weighted[6] mean number of partner organisations of 2.8. In

[4] They were however leading the Alzheimer's disease sub-project in EMIF (EMIF-AD).
[5] It is noteworthy that publications can arise well after the project end date, e.g. there were ROADMAP publications being published in August and September 2020, almost two years after the project completion. This may be relevant for projects recently completed.
[6] Weighted by total number of partner organisations per project

total there were 99 publications that only listed 1 partner organisation among the co-authors, of which 91 were from an academic organisation and 8 from an EFPIA organisation. 51 publications were authored by a single partner organisation, possibly consisting of collaborations among different researchers from the same organisation. A further 48 publications were collaborations with non-IMI partners and/or non-project partner organisations.

At a project level, excluding MOPEAD, ROADMAP had the highest mean number of partners as co-authors (6.2, s.d=3.4, range 1-11) compared to an average of 1.6 partners for AETIONOMY (s.d=1.1, range 1-7) (figure 3). Across the projects there was variation in the proportion of publications which included multiple partners as co-author. AETIONOMY (59%, 23/39) and EQIPD (57%, 13/23) had the highest proportion of project publications which only listed 1 or fewer partner organisations among the co-authors. This compared to ADAPTED and ROADMAP where all or the majority of publications included 2 or more partner organisations among the co-authors (figure 5).

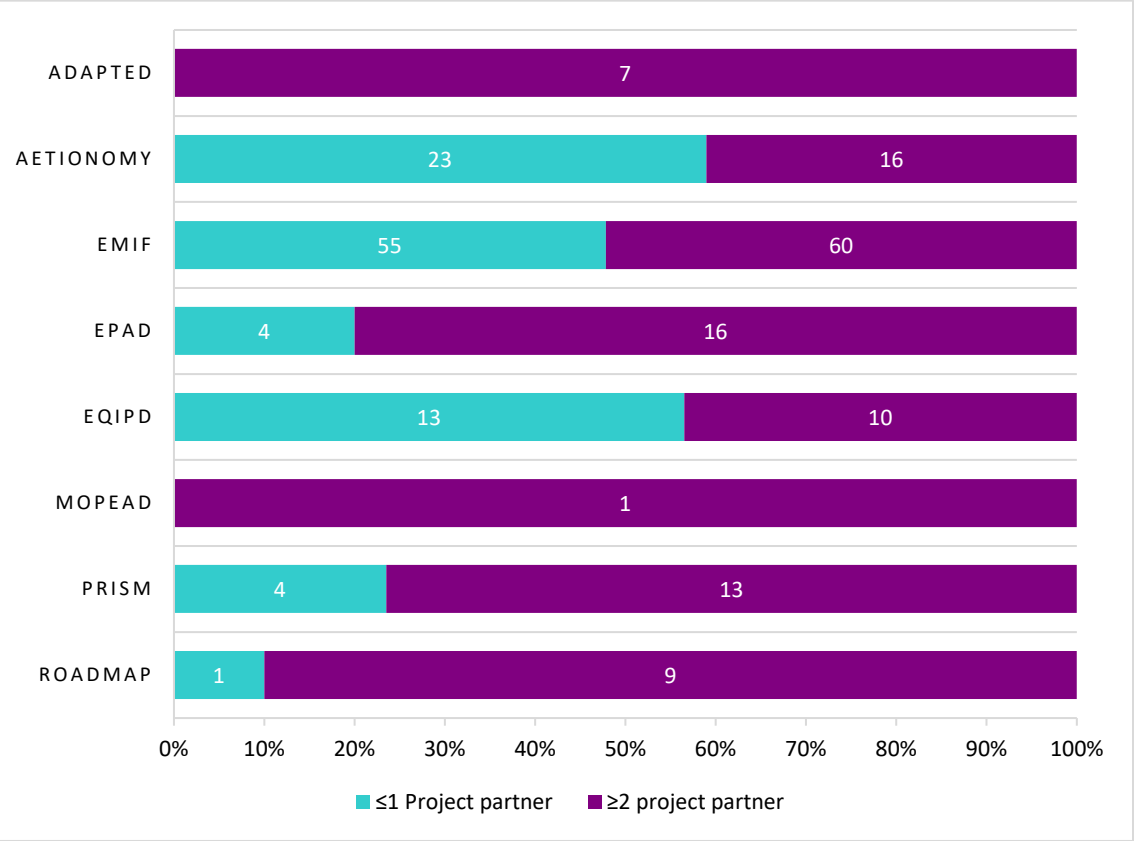



**Figure 5:** Numbers and percentage of publications with ≤1 partner organisation listed as a co-author compared to publications with ≥2 partner organisation listed as a co-author

To assess collaboration between different organisation types, we analysed the mix of organisations listed as co-authors on publications with more than 1 partner organisation among the co-authors (N=132). Across 50% (N=66) of publications there was a mix of different organisation types listed as co-authors on the publications, with collaborations between Academic and EFPIA organisations being the most common. The vast majority of the remaining (49%, N=65) publications were collaborations between different academic organisations. There was variation between the projects in terms of the mix of partner types publishing together. Purely academic collaborations were common across all projects with the exception of MOPEAD and ROADMAP, and made up the majority of publications from AETIONOMY (11/16) and EMIF (39/61) (figure 6).

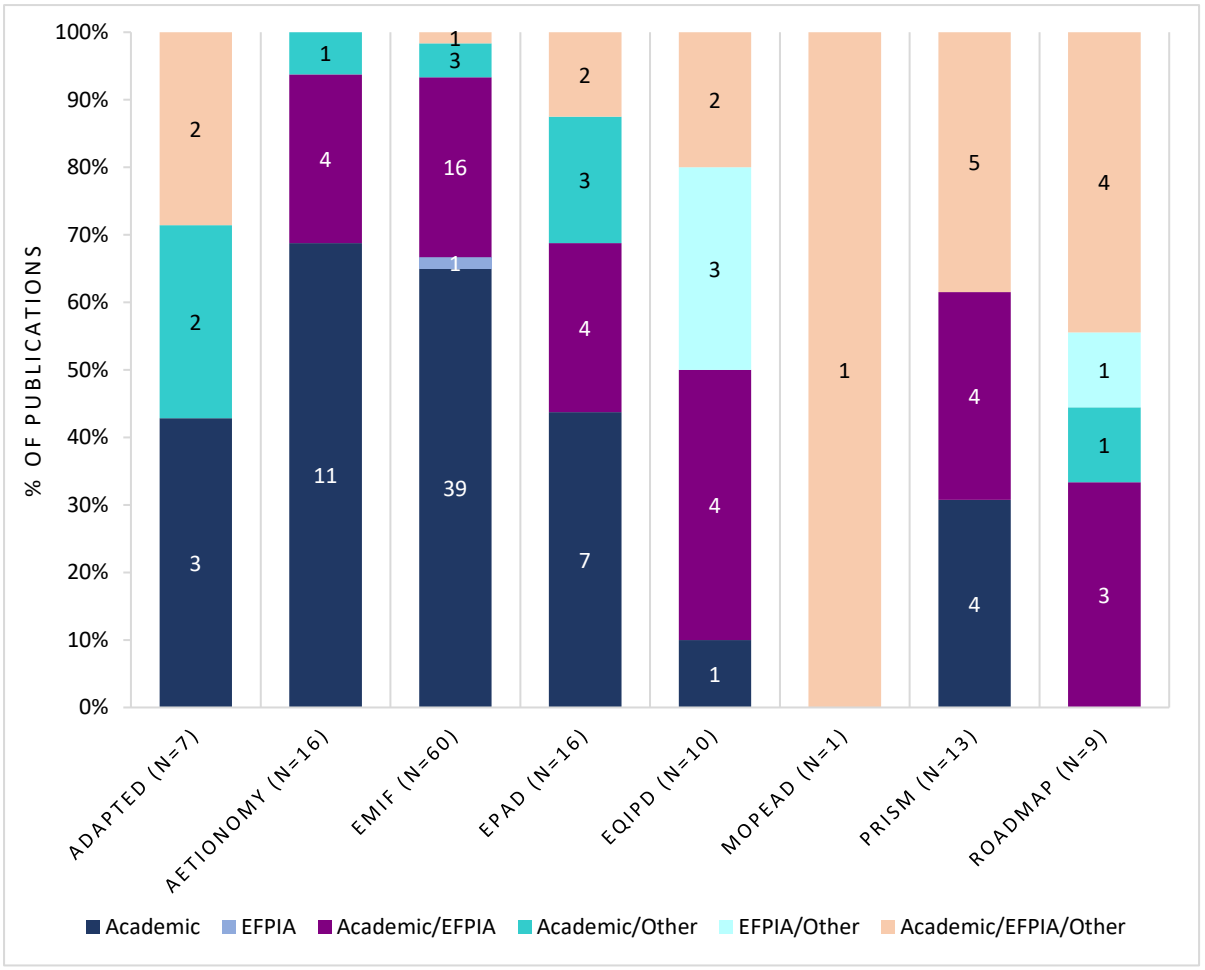



**Figure 6:** Collaborations of partner types on publications with more than 1 partner organisation listed

We calculated the proportion of publications where at least 1 non-IMI partner was listed as a co-author (table 5). This was the case in 50% of all publications (151/232) and varied by project from 23% of AETIONOMY publications (9/39) to 86% of ADAPTED publications (6/7).

| Project | Publications with non-IMI partner | % publications |
|---|---|---|
| ADAPTED | 6 | 86% |
| AETIONOMY | 9 | 23% |
| EMIF | 69 | 60% |
| EPAD | 8 | 40% |
| EQIPD | 8 | 35% |
| MOPEAD | 1 | 100% |
| PRISM | 7 | 41% |
| ROADMAP | 7 | 70% |

**Table 5:** Non-IMI partner contributions

### 4.2.2 Publications network analysis

We used network analysis to further explore the collaborations of partner organisations on publications. We excluded all publications (N=99) that only listed a single organisation among the co-authors, and we excluded all organisations that did not contribute to any publications. The network included 94 organisations who contributed to 132 publications that listed at least 2 organisations among the co-authors. We calculated the degree centrality for all organisations in the network. The degree centrality represents the number of other organisations that each partner organisation has published with (for example, if organisation A has published 2 publications with a total of 5 other organisations, the degree centrality of organisation A will be 5). The nodes in Figure 6 represent all organisations included in the network, with the size of the node determined by the degree centrality. The colours of the connections between organisations are determined by the number of publications they appear on together; orange connections indicate 2 organisations have appeared on 1 publication together, with the blue lines indicating connections between organisations who have co-authored multiple publications.

The highest degree centrality is 53 for Janssen Pharmaceutica, which means that Janssen Pharmaceutica has co-authored 30 publications with 53 other IMI organisations in the projects that it is a partner in. Table 6 gives the top 20 of collaborating organisations, as determined by their degree centrality. Sixty percent of the top 20 consists of academic organisations, and 35% of the organisations are EFPIA companies. There are no SMEs in the top 20 collaborators on publications. When we look at the number of projects, there are some organisations who managed to co-author publications with a substantial number of other partner organisations despite only participating in a single project (such as GSK, who are only participating in EMIF, but did contribute to 5 publications with a total of 26 organisations among its co-authors (table 6).

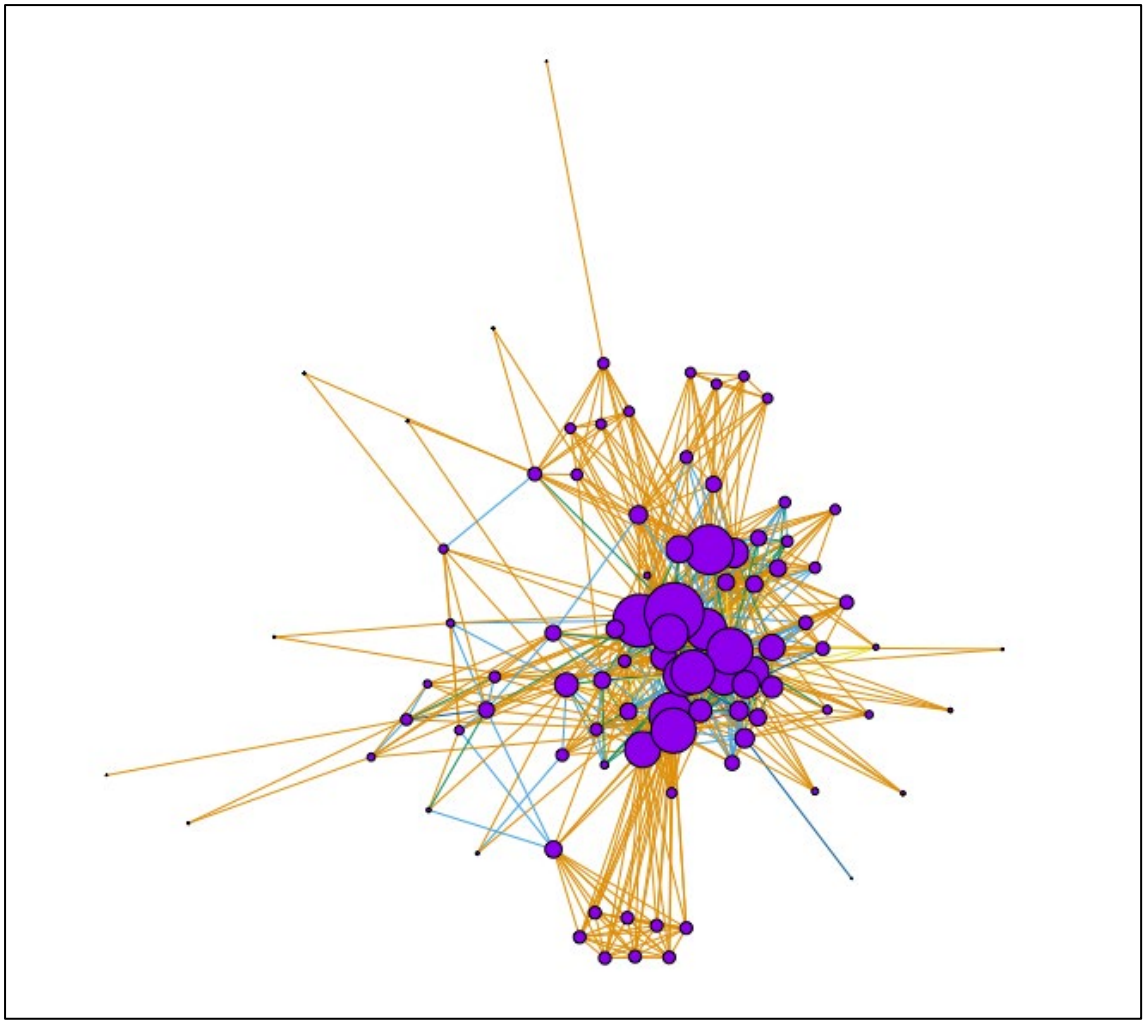


**Figure 7**: Network analysis of collaborating organisations on publications. The size of each node reflects the 'degree centrality' (the number of other organisations that each partner organisation has published with). The colour of the connections represents the number of publications which connect individual organisations. Orange connections = 2 organisations have appeared on 1 publication together; blue connections = organisations who have co-authored multiple publications.

| Organisation | Type | Projects (N) | Publications (N) | Degree |
|---|---|---|---|---|
| Janssen Pharmaceutica | EFPIA | 6 | 30 | 53 |
| Erasmus Medical Center | Academic | 6 | 22 | 47 |
| Pfizer | EFPIA | 4 | 7 | 44 |
| Stichting Vumc | Academic | 3 | 39 | 41 |
| Eli Lilly | EFPIA | 4 | 12 | 40 |
| Karolinska Institutet | Academic | 4 | 16 | 40 |
| University of Oxford | Academic | 3 | 26 | 39 |
| F Hoffmann La Roche | EFPIA | 5 | 12 | 37 |
| Universiteit Maastricht | Academic | 2 | 23 | 36 |
| The University of Edinburgh | Academic | 3 | 16 | 34 |
| Alzheimer Europe | Patient/carer organisation | 5 | 9 | 32 |
| Goeteborgs Universitet | Academic | 2 | 20 | 31 |

| | | | | |
|---|---|---|---|---|
| Institut National De La Sante Et De La Recherche Medicale | Academic | 2 | 23 | 28 |
| Glaxosmithkline Research And Development | EFPIA | 1 | 5 | 26 |
| Stichting Katholieke Universiteit | Academic | 3 | 8 | 24 |
| Universiteit Antwerpen | Academic | 1 | 16 | 24 |
| Boehringer Ingelheim | EFPIA | 5 | 10 | 23 |
| Kings College London | Academic | 1 | 21 | 23 |
| Biogen | EFPIA | 3 | 7 | 21 |
| Provincia Lombardo Veneta Ordineospedaliero Di San Giovanni Di Dio Fatebenefratelli | Academic | 1 | 7 | 21 |

**Table 6**: Top 20 collaborative organisations in project publications

### 4.2.3 Publication qualitative analysis of framework

We reviewed 232 project publications and excluded 86 publications because they did not report new knowledge generated within the project (review articles, study protocols, and editorials). A total of 146 publications across the 8 IMI projects were included in the final analysis: 117 publications were themed into one or more of the 5 categories from the 'Framework for scientific priorities in neurodegenerative diseases' as described in section 3.1.3 above. The publications (N=29) that didn't fall into one of the themes from the framework were then assessed and categorised into one of the 8 enabling activities set out in the JPND report.

#### *4.2.3.1 Scientific Priorities*

We classified 117 publications into 1 or more of the 5 key themes and then sub-categorised within those themes. The majority of publications were classified as themes 1 and/or 3 (84/117) (table 6) indicating that most projects in this analysis were largely clinical in focus.

| Theme | Publications (N) |
|---|---|
| 1) The origins and progression of neurodegenerative diseases | 32 |
| 2) Disease mechanisms and models | 16 |
| 3) Diagnosis, prognosis and disease definitions | 48 |
| 4) Developing therapies, preventive strategies and interventions | 10 |
| 5) Health and social care | 1 |
| 1 & 2 | 4 |
| 1 & 3 | 4 |
| 2 & 3 | 2 |

**Table 6**: Project publications by key theme

Figure 8 provides an analysis of all publications by theme and category and shows some clustering of publications around certain categories within the themes, with some publications touching on 1 or more sub-category within a theme.

Theme 1 covers research aimed at improving knowledge about the disease causes, progression, and key risk factors for neurodegenerative diseases. 60% (N=18/32) of the publications in this category came from the EMIF project and all publications focused on Alzheimer's disease and dementia, or neurodegenerative disease in general. Across this theme there was a spread of publications looking to understand more about existing risk factors of neurodegeneration and look for potential biomarkers, and on the association of brain atrophy and cognitive decline. An article of particular interest was a 2015 EMIF publication with 488 citations to date. The findings of this publication suggest

that there is a 20- to 30-year interval between first development of amyloid positivity and onset of dementia, a finding now widely accepted.

Several categories in Theme 1 were only partially covered, including: a lack of long term aging studies to understand aging in the context of neurodegeneration; a lack of studies looking at the molecular mechanisms of aging; and limited examples of how genetic and environmental factors interplay in the origins and progression of neurodegeneration.

Theme 2 focuses on research to develop a comprehensive understanding of the underlying disease mechanisms, through novel and improved existing animal and cellular models of neurodegeneration, to inform the development of new diagnostic and therapeutic approaches. Most of the publications in this theme came from the AETIONOMY project. The wealth of clinical and biomarker data available in several projects enabled a number of publications developing computational models of neurodegeneration pathogenesis to identify disease hypotheses (N=9). In addition, a handful of publications looked at reverse translation for animal models that will be useful for mechanistic studies (N=4). Analysis across different neurodegenerative diseases examined the interplay between multiple mechanisms, including analyses of neuropsychiatric symptoms such as sleep disorders in Alzheimer and schizophrenia.

Theme 3 focuses on the development of new or improved diagnostic tools and the identification of novel biomarkers, to enable earlier and more accurate detection or diagnosis of neurodegenerative diseases. The vast majority of the publications in this category came from the EMIF project, dating back to 2014 and focused on Alzheimer's disease and dementia; there are no publications on Parkinson's disease or other neurodegenerative disorders. The most recent article was published in 2019, by the EPAD project. There was a strong focus on biomarkers, broadly falling into three categories: plasma, cerebrospinal fluid (CSF) and neuroimaging biomarkers. Of these three categories, research identifying and/or assessing the validity of novel biomarkers were focused on plasma or CSF compartments, including non-coding RNAs alongside blood lipids and metabolites. Approximately half the publications were focused on CSF or plasma proteins with substantial evidence implicating them in the development of dementia, including proteins such as beta amyloid, Tau, neurofilament light chain (Nfl) and TREM2. A secondary theme addressed by publications in this category was the use of biomarkers for risk prediction in people with prodromal AD/mild cognitive impairment. With 207 citations to date, an article of particular interest was a 2015 Brain publication from the EMIF project, on a large-scale study assessing the predictive accuracy of different clinical criteria for prodromal AD in people with mild cognitive impairment (MCI).

Theme 4 covers research on preventive strategies and interventions to reduce the risk of developing neurodegenerative disorders or to promote the capacity of the brain to resist disease, as well as speeding up the translation of basic findings covered by other themes to provide clinical benefit. The majority of publications (N=7) in this theme came from the EPAD project and related to ethical issues, for example, ethical issues relating to the disclosure of the risk status for developing a disease to healthy study participants. One paper of particular interest was a 2018 EPAD publication which presented the results of a qualitative focus group study. This study explored the attitudes and concerns of healthy research participants and people with dementia and their caregivers towards learning their biomarker-based risk status and their preferences about how that risk-status is disclosed.

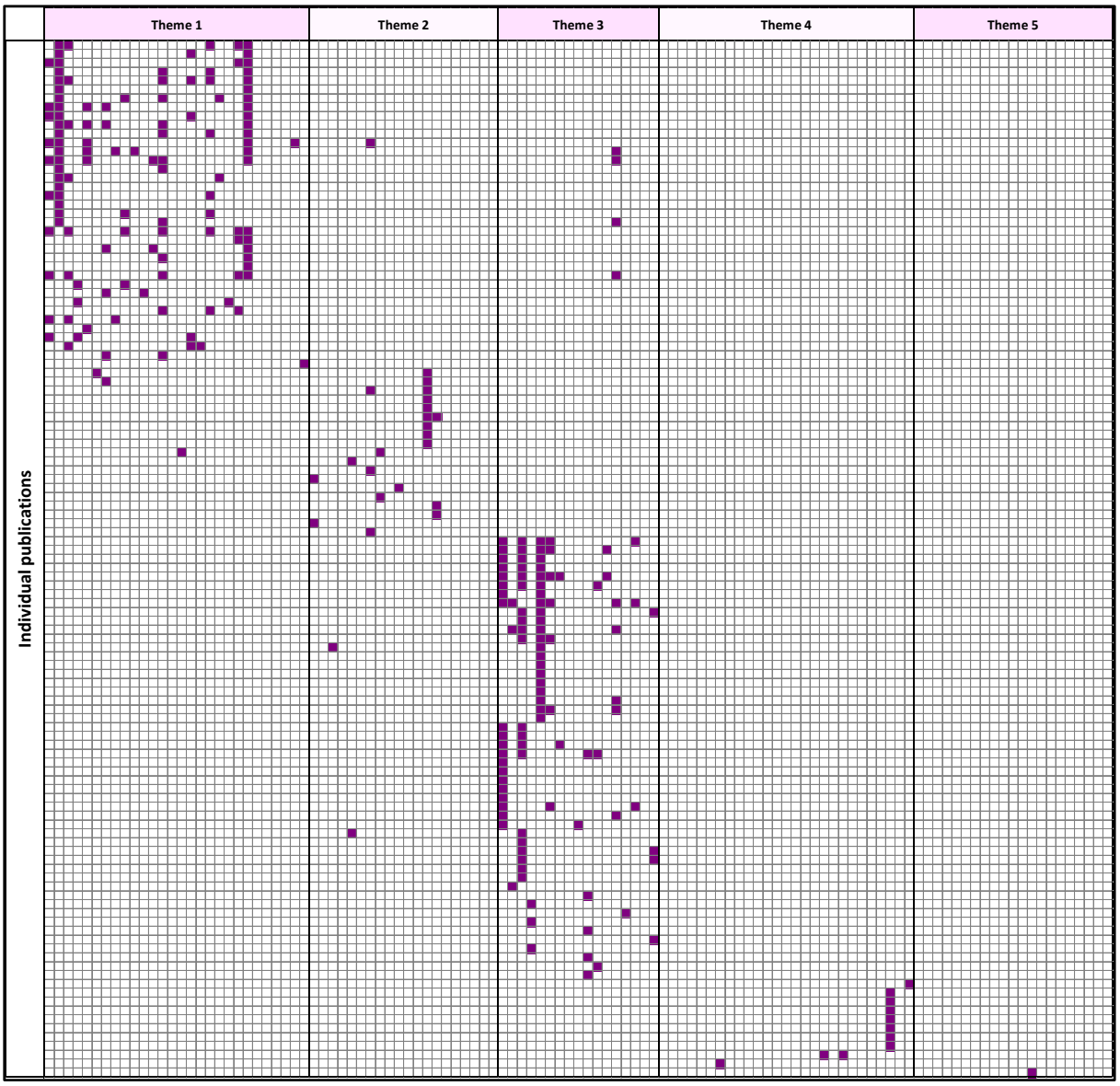



**Figure 8**: Heatmap of project publications (rows) by theme and sub-category (columns)

#### *4.2.3.2 Enabling activities*

29 project publications were identified that did not fit within 1 of the 5 scientific priority themes. These publications were then assessed against the 8 enabling activities set out by the JPND report and classified where applicable. The majority of publications in this group were categorised in the 'Supporting infrastructure and platforms' theme and mainly related to software and architecture to support the sharing of data.

| Enabling activity | Publications (N) |
|---|---|
| Supportive infrastructure and platforms | 26 |
| Working with regulatory organisations | 2 |
| Education and training | 1 |

**Table 7**: Project publications by enabling activities

# 5 Discussion

## 5.1 Project analysis

### 5.1.1 Main findings

The IMI neurodegeneration project portfolio that we included in this impact analysis encompasses 18 IMI projects in total, of which 8 projects have been or are about to be completed. A total of 239 organisations participate in the 18 IMI projects. There are 135 academic organisations, 31 EFPIA companies, 53 SMEs, 7 patient/carer organisations, and a small number of other types of organisations (including research funders, a regulatory agency, and an HTA body) that make up the organisations in the project portfolio.

Thirty-six percent of organisations (N=87) participated in multiple projects in the portfolio. Academic organisations represent 56% (N=135) of all organisations across the 18 projects and EFPIA partners represent 13% (N=31) of all organisations, but by construction EFPIA partners participate in multiple projects much more frequently: 38% of academic organisations participated in multiple projects, and 71% of EFPIA partners participated in multiple projects. Janssen Pharmaceutica (Belgium) participated in most projects by far (13 IMI projects in total).

The network analysis revealed that there is a relatively small number of organisations that form the key nodes in the network of IMI project organisations, the majority of which participate in the largest projects in the portfolio. These organisations form the key links between different IMI projects, which can facilitate dissemination and exchange of knowledge/experience generated in the projects. They therefore may play an important role in increasing the impact of IMI neurodegeneration projects. Here, academic organisations are underrepresented, and the majority of key nodes are EFPIA companies. This result can be expected since the number of participating EFPIA organisations is much smaller than the number of eligible public partners, and under IMI2 there was a need for more than 3 EFPIA organisations per project. As key nodes in the network, EFPIA companies may have more opportunities to create synergies across the portfolio than academic organisations or SMEs, whose involvement in multiple IMI projects is more sporadic.

There is some clustering of groups of organisations who collaborate with each other across multiple projects: ROADMAP, EPAD, EMIF and PRISM share a fair amount of the same organisations, whereas other projects share far fewer organisations with the rest of the project portfolio. For such projects (such as PD MIND, MOPEAD or ADAPTED), it could be more likely that new knowledge that is generated by these projects might be suboptimally leveraged due to the lack of connections to the rest of the project portfolio. This is particularly relevant for PD-MIND in which only 2 of the key nodes in the network of IMI project organisations participate. Neuronet, given its role in providing support and coordination across the portfolio, should therefore consider how it can provide additional support to these projects to ensure that key outputs are not missed by other IMI neurodegeneration projects, and, conversely, that results from other projects are leveraged as appropriate in these more “isolated” projects.

Although some organisations participate in large number of projects, this is not to say that within these organisations, the same people and departments are involved in multiple projects. Within large organisations, it is frequently the case that different teams and departments are involved in different

projects and might not be aware of what their colleagues are working on. Given that organisations that participate in multiple projects might have the lowest barriers for sharing of new knowledge, IMI could consider targeting organisations that participate in multiple projects and offer support and guidance to ensure that knowledge from different projects is disseminated and shared. Along similar lines, our analysis makes apparent that EFPIA companies are by IMI construction the key nodes in our analysis, and provide the key vehicles for dissemination of knowledge generated between projects, to ensure tools, methods and experience developed by a project are shared within organisations and between projects.

## 5.2 Publication analysis

### 5.2.1 Main findings

We included 232 publications from the 8 IMI projects that have or are about to complete their work. We found variation in the number of publications per project, the number of publications per partner organisation, and the number of partner organisations listed as co-authors on a publication. Comparison with the number of assets resulting from each project showed no specific pattern. EMIF is the project with the highest number of publications (N=115) and MOPEAD has the lowest number of publications (N=1). The number of partner organisations listed as co-authors ranged from 1 to 13, with a weighted average of 2.8 organisations per publication. The single organisation with the highest number of publications is Stichting VUMC (N=48), who participated in 3 of the 8 IMI projects, followed by Janssen Pharmaceutica (N=32) who participated in 6 out of 8 IMI projects.

The analysis showed differences between the projects both in terms of the average number of partner organisations listed as co-authors on project publications, and the involvement of different organisation types on project publications. The results might suggest that projects with a higher average number of partner organisations as co-authors and with a greater mix of organisation types represented are more ‘collaborative’ than others. However, this analysis does not take into account the type of publication, where for certain types you might expect to see greater collaboration (such as commentaries on the project itself), nor the differing authorship policies that may be established in different projects (e.g. with relation to use of data). Furthermore, we have not analysed how the publications relate to project deliverables or project assets and the expected collaborations and resource related to these. Finally, it has to be underlined that in some cases publications are only visible well beyond the completion date of a project.

When we explored the level of collaboration on publications among project partners, we find that Janssen Pharmaceutica collaborated with the most other organisations among the projects, even though it did not publish the most out of all organisations included in the analysis. Unsurprisingly, academic organisations comprise the majority of top-collaborators on publications (60% of the top 20 collaborators).

However, we also found that 42% (N=99) of all publications did not list more than 1 IMI project partner among the co-authors. Given that all projects are large collaborations with dozens of partner organisations involved, it seems that a substantial part of the knowledge generated in the IMI neurodegeneration portfolio happens within single organisations without much involvement of other project partners. While this may be a direct consequence of specific work breakdown structures in

which entire tasks or work streams depend on only one partner, we question whether this is the optimal way for knowledge generation and transfer between organisations.

Furthermore, we find that 47 of the 142 organisations included in the publication analysis did not contribute to any of the publications. Although it is inevitable that some partner organisations will not contribute to publications at all, this still is a substantial proportion of the organisations involved in the projects (33% of all organisations included in the analysis).

We also find that SMEs contribute less to publications than academic organisations and EFPIA companies, with some notable exceptions. This could partially be explained by some of the SMEs performing technical or project management tasks that might be less suited to publication in peer-reviewed journals. However, we also found that 17 academic organisations did not contribute to any publications at all.

It is notable that the most successful collaborators are all based in a few countries, and it is possible that organisations from other countries, especially central and Eastern European countries, are less often part of the most productive sub-networks of partner organisations who collaborate across projects and publish together. However, half of publications in our analysis included a non-IMI project partner as a co-author, indicating that projects are actively collaborating beyond the scope of IMI in undertaking their research, and possibly with partners from other countries beyond the few represented in our analysis. Further research into the nature of these collaborations may provide further insight into how the IMI portfolio is linking to global research efforts in this field.

Our results from the qualitative analysis of project publications show that the generation of new knowledge has been focused on more clinical areas, perhaps reflecting the focus of the projects included in this analysis. However, this analysis does not take into account the broader outputs developed by the project portfolio. Further work is therefore needed to assess how project assets are also contributing towards research across the priority scientific areas.

# 6 Conclusion

The IMI neurodegeneration portfolio, encompassing 18 different projects and 239 unique organisations, works across a range of topics and diseases. There is a fair amount of clustering in the network of organisations that make up the project portfolio, with about one-third of academic organisations and more than 70 percent of EFPIA companies participating in more than 1 IMI neurodegeneration project. SMEs, however, participated in multiple projects much less frequently, with only 21 percent of SMEs participating in more than 1 of the 18 projects.

It is impossible to say what the optimal amount of clustering to facilitate innovation in a given network is. Too few links between projects make it more likely that new assets being developed by one project go unnoticed by other projects. However, too much clustering across organisations make it more likely that suboptimal methods are adopted and not replaced. Our analysis allows for a couple of observations: first, the EFPIA companies have many more possibilities than academic partners to facilitate the exchange of new knowledge and promote uptake of tools and assets developed by

individual IMI projects. Furthermore, given the IMI objectives of speeding up drug development, it is essential for EFPIA companies to adopt the knowledge generated by projects, if the portfolio is to achieve impact. This may call for a more active role of structures such as the EFPIA-led Strategic Governing Groups in terms of monitoring the assets resulting from the different projects. Here the role of Neuronet may be relevant.

We also see that whilst there are some projects which share a greater number of organisations, other projects have far fewer connections with the rest of the project portfolio. In particular, there are fewer links between the projects focusing on Alzheimer's disease and those focusing on Parkinson's disease. Neuronet should facilitate the exchange of knowledge between projects primarily addressing discrete diseases to ensure that opportunities for knowledge transfer that could benefit the projects are not missed.

We found that a significant number of publications coming out of individual projects were only authored by authors from a single institution, and that when multiple organisations were co-authors on publications, these were collaborations between academic partners much more often than between EFPIA and academic partners. This could be explained by the importance of scientific publications for authors who work in academia versus those in other organisations, and the different internal procedures pharmaceutical companies might have to facilitate publication in peer reviewed journals. It can also be a consequence of work breakdown structure in different projects - some projects may have more specialised partners siloed in certain pieces of work, whereas other projects may rely more on collaborations across partners to deliver the intended results. However, as the ultimate objective of IMI is to speed up drug development, the low number of EFPIA and academic collaborations on publications could indicate that EFPIA partners might not consistently shape and influence academic work to the extent that they end up as co-authors on project outputs. This in turn could lead to sub-optimal assets being produced that end up being of high academic quality but with less relevance or application downstream in pharmaceutical drug development.

# 7 Next steps

This is the first version of the project impact analysis and has generated some insights into the IMI neurodegeneration portfolio. It has provided Neuronet with some interesting findings that warrant more in-depth analysis. We will explore the following findings in more detail in the second version of the impact assessment (D1.7), due in month 36, at the end of the project:

- Further analysis of the reasons for single organisation publications and any potential impact this has on knowledge generation and transfer between organisations. Further work could also explore why certain organisations do not participate in publications and whether or not this hinders the transfer of knowledge;
- Research into the nature of collaborations may provide further insight into how the IMI portfolio is linking to global research efforts in this field;
- Qualitative research looking more broadly at the use and impact of project assets, particularly by EFPIA. This research could also explore the impact on EFPIA of collaborations with other partner types through IMI projects, as well as the impact on personal and professional development and the creation of opportunities for early career researchers.

Finally, Neuronet has actioned the following steps as a result of the findings:

- Neuronet will consider how it can provide additional support to the least well connected projects in the portfolio to ensure key outputs are not missed by other IMI neurodegeneration projects;
- Neuronet recommends to IMI that it should consider targeting organisations that participate in multiple projects and offer custom support and guidance to ensure that knowledge from different projects is disseminated and shared.