Infect-ERA
Final report

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Final publishable summary report

1 AN EXECUTIVE SUMMARY (NOT EXCEEDING 1 PAGE).

Infectious diseases (ID) cause tens of thousands of deaths each year in Europe. Despite all the measures taken to address the ID, different factors have contributed to the more recent ID' challenges: (i) the threat of emerging ID (16 new and 5 re-emerging ID were identified in the last two decades - NIH), (ii) mass migration, global travelers and growth of congested urban slums, (iii) misuse and overuse of antibiotics (iv) co-infection with at least two pathogens. Hence, continuous global effort and novel avenues of research are required to decipher the role of the new factors in the development of ID. New diagnostics, bioassay and bio-marking tools and methodologies need to be developed through novel approaches that combine basic and applied research.

The challenges of ID have no borders and they need to be addressed through international innovative research that integrates interdisciplinary approaches and fosters multi-disciplinary collaborations (clinicians, researchers, industrial partners, etc). The collaboration at European level is necessary to share know-how, to address gaps, and to develop appropriate and universal diagnostics and preventive measures including vaccines. To address the ID issues at the ERA level, Infect-ERA has expanded the established network of National Funding Bodies that participated in the ERA-NET PathoGenoMics (PGM, 2004 – 2012), which the scope was concentrated on the Genomics of Microorganisms particularly bacteria and fungi. The consortium of the ERA-NET Infect-ERA was composed of 14 agencies from 11 countries collaborating to address human ID caused by bacteria, viruses, fungi and protozoa.

Through this initiative, Infect-ERA partners came together to coordinate and align their national activities to further understand all basic aspects of human infection biology questions. The Infect-ERA consortium launched four Joint Transnational Calls (JTCs) and financed research in the amount of 31,5 M€ by supporting 34 research projects involving 163 research groups. The funded research aims to address the complex relationship between the microbes' environment and their molecular strategies of infection, and also integrates new approaches and technologies such as metagenomics, and systems biology. They are also tackling the cross talk between the host and the microbes, including transmission of mircororganisms and the role of host susceptibility factors. In addition, some of the funded projects aim to develop biomarkers, preventive, diagnostic and therapeutic tools. About 88% of the Infect-ERA funded projects could be categorised according to the thematic of the European Centre for Disease prevention and Control (ECDC) programmes showing that Infect-ERA funds research to combat diseases of global importance.

Infect-ERA has contributed to feed the ID community by publishing useful information on ID field on its website. This information consists of existing national and European funding programmes, research infrastructures and information on researchers' profile created by the researcher her/himself. In addition of funding measures targeted, Infect-ERA has supported the development of young scientist's career by organising workshops dedicated to the opportunities in the ID field, the protection of intellectual properties, the creation of start-ups, the scientific writing or networking activities. Finally, Infect-ERA has developed a long term cooperation framework concept including a scientific strategy with the elaboration of a Strategic Research and Innovation Agenda (SRIA), a plan to strengthen its transnational collaboration, and the monitoring of its activities to improve its management and operation. Finally, Infect-ERA identified the ERA-NET Cofund as an instrument to follow its collaboration in an optimum way. Infect-ERA partners are lobbying the member states and the European Commission to have a possibility to propose a new initiative based on the results of PGM and Infect-ERA. In addition of the topic identified in the SRIA, Infect-ERA partners agreed to broaden the scope of the new initiative by integrating the diseases tuberculosis, HIV and malaria but also to

deeper knowledge and surveillance of pathogens, their host, their vectors and their propagation in sort to anticipate new epidemics.

2 A SUMMARY DESCRIPTION OF PROJECT CONTEXT AND OBJECTIVES

Infect-ERA is an ERA-NET for research programmes on infectious diseases (ID) funded under the European Commission's 7th Framework Programme from January 2013 to December 2016.

The ERA-NET serves as a platform for funding agencies and ministries to coordinate transnational collaborative research in the field of ID through yearly joint transnational calls (JTC), which is one of the most important and effective Infect-ERA activities. ID cause tens of thousands of deaths each year in Europe and have an important negative impact on the economy, due to the direct cost of their treatment, but also the loss of workdays and productivity. Despite all the measures taken to address the ID, different factors have contributed to the more recent ID' challenges: (i) the threat of emerging ID (16 new and 5 re-emerging ID were identified in the last two decades - NIH), (ii) mass migration, global travellers and growth of congested urban slums, (iii) misuse and overuse of antibiotics (iv) co-infection with at least two pathogens (for instance in persons infected with HIV, the prevalence of Hepatitis C is estimated to be ~50%). In order to design adapted treatments, as well as diagnostic and preventive tools, the research funded in Infect-ERA were aiming at understanding basic aspects of human infection biology caused by bacteria, fungi, viruses and protozoa. With a wide scientific scope, Infect-ERA was aiming to understand complex infection biology questions such as co-infection that are not limited to specific pathogens.

To that end, research addressing the cross-talk between host and pathogens and infection was planned to be supported by Infect-ERA. In addition, this ERA-NET aimed to (i) strengthen the development and improvement of innovative tools and methodologies to address infection biology as a whole and (ii) promote the integration of new tools to carry out research. To address the ID issues at the ERA level, Infect-ERA was expanding the established network of National Funding Bodies that participated in the ERA-NET PathoGenoMics (PGM, 2004 – 2012) that concentrated on the genomics of microorganisms particularly bacteria and fungi. The Infect-ERA consortium has been constituted from a part of the PGM consortium and also new funding organisations, which lead to 14 agencies from 11 countries collaborating to address human ID. Infect-ERA was capitalising on the accomplishments of PGM, which notably launched three successful JTCs (JTC 2006, 2008 & JTC 2010) and focused its effort on the development of the young research communities. Therefore, the main objective of Infect-ERA was to deepen and extend the PGM consortium and go further in supporting transnational research projects, through the launch of yearly joint calls for proposals on ID (except HIV, tuberculosis and malaria dealt in the FP7 HIVERA cooperation; WP3). The Infect-ERA consortium was also aiming to contribute to European mobility and overall training of young scientists to create further synergies between existing European structures and to pave the way for sustainable cooperation in ID by facilitating young scientists' training in collaboration with companies and to enhance their training through specific support measures including targeted transnational funding measures and networking activities (WP3 and WP4).

The External Advisory Board (EAB) workshops were designed to gather and share research expectations from the EAB members and other stakeholders in order to address the current challenges in ID. The suggested topics of high importance formed the basis of the Strategic Research and Innovation Agenda (SRIA) of Infect-ERA. In parallel, several mapping to identify programmes, initiatives, and Research Infrastructures in Infect-ERA partners' countries and beyond as well as a bibliometric study allowed to capture the various European stakeholders in ID and develop a strategy for Infect-ERA (WP2 and WP7).

One of the objectives of Infect-ERA was to work on sustainable cooperation framework. To reach sustainability the outcome of several ongoing Infect-ERA activities was considered: (i) monitoring the performance of Infect-ERA activities and evaluating their impact and (ii) benchmarking with sister initiatives. In order to assess its performance and meet the partners' and scientific community's expectations, monitoring indicators were to be defined at the start of the project (WP5). To work

towards exploring the different operational and administrative procedures possible for a long-term sustainable collaboration, exchange information and benchmarking with sister initiatives were planned.

To enhance communication and facilitate information exchange within the ID community, Infect-ERA plan was to develop different tools available on its website to facilitate collaborations e.g. a list of existing funding programmes, a search tool for research infrastructures and also for researchers containing their contact information and description of their research interests. Infect-ERA actively communicated on the activities it carries out through its website, social media, press releases, flyers, video clips and newsletters to the public and particularly to the scientific community (WP6).

3 A DESCRIPTION OF THE MAIN S&T RESULTS/FOREGROUNDS

Funding transnational research and innovation in the human ID

Infect-ERA partners have come together to coordinate and align their national activities to further understand all basic aspects of human infection biology questions such as co-infection that are not limited to specific pathogens, the cross-talk between host and pathogens, as well as the relationship between microbes' environment and infection. Four calls have been implemented during the Infect-ERA duration to fund high quality and cutting edge transnational and translational research bringing together basic, applied, technology-driven and clinical research approaches to a broad variety of topics of human ID. The selected topics of JTCs was identified by the EAB and prioritised by the funding organisations. So, Infect-ERA funded cutting edge of research. For example, in 2014, Infect-ERA funding organisations have launched a JTC on the assessment of the role of commensal flora in homeostasis and the pathogenicity of microbes, and on the elucidation of how the commensal organisms or probiotics can be used to prevent or treat infections. Nowadays, the microbiome is a high priority topic at the European level. The fourth calls, regardless the topic of the call, were supporting (i) the application of novel approaches and technologies such as metagenomics, metabolomics, and mass spectrometric analysis to address infection biology and (ii) the integration of new approaches to understand the effect of the pathogen upon its interaction with the host and to develop biomarkers, preventive, diagnostic and therapeutic tools. In addition, Infect-ERA was promoting multidisciplinary collaboration by asking a close cooperation between academic and clinical and/or industrial participants to allow the generated results to go further in the research and

innovation chain. In this goal, the applicants to the JTCs had to present the application of the expected project results, which should demonstrate a clear benefit to the public. The Infect-ERA JTCs showed a growing interest in the scientific community with a consistently increase of number of applicants each year. While the PGM JTCs were focused on project with two types of microorganisms, bacteria and fungi, Infect-ERA calls were also opened to projects studying diseases caused by virus and protozoa. Interestingly, these two scientific communities well applied to the call with a rate of participation from 30% to 35% in the different JTCs. Those rates are proportional to the virus and protozoa communities, knowing that during the period 2010-2014, 38% of the published

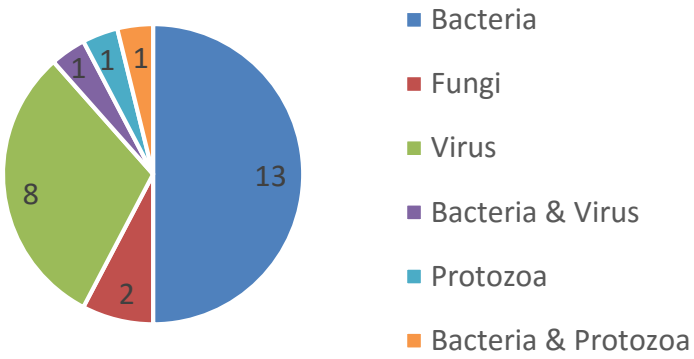

Figure 1: studied microorganisms in Infect-ERA funded projects

papers on ID was studying virus or protozoa (ref: bibliometric study made under the frame of Infect-ERA, see below; as the scope of Infect-ERA, the study was not considering HIV publications). In addition, including these two types of microorganisms allowed to the applicants to submit proposals dealing with several microorganisms at once (see figure 1).
Through its four JTCs, Infect-ERA supported 34 transnational research projects involving 163 research groups coming from 10 different European, one associated and one international countries. The public investment is of 31.5 M€. The projects funded in Infect-ERA JTCs have been categorised according to the different programmes of the European Centre for Disease prevention and Control (ECDC). Two additional categories have been added to be able to classify four projects: treatment or prevention of diseases via manipulating the microbiota and "other", which includes projects studying the relation between the host and two fungi, *Cryptococcus* and *Aspergillus* (see table 1). About 88% of the Infect-ERA funded projects could be categorised according to the thematics of the ECDC programmes showing that Infect-ERA funds research to combat diseases of global importance. In addition, Infect-ERA has a precursory role to support the scientific communities to study the putative role of microbiota to treat or prevent ID (JTC2, edition 2014, see above).

Table 1: Thematic classification of the Infect-ERA funded projects. The categories indicated with "*"correspond to the different diseases programmes of the ECDC.

Name of the category	**Number of Infect-ERA projects**
Vaccine-preventable disease*	9
Emerging and vectorborne disease*	7
Food- and waterborne diseases and zoonoses*	5
Sexually transmitted infections, including bloodborne viruses*	5
Antimicrobial resistance and healthcare associated infections*	3
Microbiota for treatment or prevention of diseases	2
Other	2
Respiratory tract infections*	1

Results of the funded research projects and networking

It is of high importance to follow-up the funded projects to have a vision of outcomes of the funded research. The follow-up and monitoring of Infect-ERA projects was performed by two different measures: face to face meeting with the coordinators of the projects as well as reports about the progress of the projects.

Face to face meetings:

Three types of meetings have been organised between the Infect-ERA consortium and the coordinators of the funded projects, namely, kick-off meeting, mid-term and final status seminar meeting. The kick-off meeting has different aims: (i) explaining to the coordinators how the project will unfold, (ii) giving the expectations of the Infect-ERA consortium (e.g. scientific and financial reporting, communication on project results or organised events), (iii) disseminating about the tools that Infect-ERA was implemented for the scientific community (see section Sharing the information with the ID community and general public), (iv) facilitating the networking between the funded consortia since its beginning and (v) presenting the funded projects to Infect-ERA External Advisory Board (EAB).

The mid-term and final status seminars had as main objective to assess the progress of the funded research projects. With this aim, three to four members of the peer review panel (PRP) were invited to the status seminars and reported to the funders about their impression on the progress of the projects. The EAB was also invited to those events. The mid-term and final status seminars were set up in two different configurations: either the meeting was open only to the coordinators of the Infect-ERA or joined with another event. Thus, the final status seminar of the last PGM call and the mid-term status seminar of Infect-ERA JTC1 were organised in a restricted meeting whereas the mid-term status seminar of Infect-ERA JTC2 and the final status seminar of Infect-ERA JTC1 were organised together and in collaboration with the final meeting of the INBIONET, a Marie Sklodowska Curie initiative. In addition to the project coordinator, young scientists of the Infect-ERA funded consortia were also invited to stimulate networking amongst young researchers of different networks but also with the senior researchers (see supporting young scientists section). A total of 84 participants were present at this INBIONET-Infect-ERA conference. The invited PRP members reported to Infect-ERA that nearly all projects (JTC1 and JTC2) were progressing according to the planed work or even beyond except for few of them which had minor technical problems but the consortia were well reacting to unlock the situation.

Reporting on the project progress

The report templates by the coordinators are asked to fill in at the mid-term and final term of the project. They include a part for the description of the results but also a part, which allows the collect of outcomes indicators established on the expectations of Infect-ERA partners (see section implementation and monitoring of Infect-ERA activities). Different sets of indicators have been developed to assess specific dimensions of the projects as scientific communities' call outputs, socio-economic impact of funded projects and scientific communities' networking These indicators have been collected and analysed for the last call of PGM and the JTC1 and JTC2 projects at mid-stage. The collection of the indicators for JTC1 projects highlighted the added-value of the transnational and multidisciplinary collaborations in term of knowledge and resources exchanges. After 18 month of the

projects start, those projects enabled the mobility of nine researchers and the creation of 34 jobs. All consortia exchanged bioresources and knowledge on procedures or technics. The analysis showed already 41 publications of high quality, as 50% of the publications have been published in a journal with an impact factor above five.

Sharing the information with the ID community and general public

Existing funding programmes:

In order to assist and maximize the scientific community's capacities to face the global challenges, all national funding programmes susceptible to fund the ID field have been indexed by the Infect-ERA partners and published on the Infect-ERA website. Those include national funding programmes to support research, non-research and young scientists' activities (http://www.infect-era.eu/fundings) as well as cross boarder funding programmes (http://www.infect-era.eu/cross-boarder-fundings). The mapping on "cross border funding" allowed identifying 30 different programmes at the European and national levels. Those programmes are either in biomedical sciences or in human ID. As for the national programmes, the cross border funding allows collaborations between national and foreign scientists, national scientists to work abroad and scientists from abroad.

In addition, sister initiatives provinding research funding activities and support to the ID community have also been identified and promoted on the Infect-ERA website (http://www.infect-era.eu/initiatives/international).

Facilitating the collaboration between researchers and research organisations:

To support cooperation between researchers and enhance the development of a European research area, a database of researchers has been implemented on the Infect-ERA web-site. The interested researchers had to register themselves on the website describing their research topics, the microorganism(s) studied and the special methods or technologies used. The profile should be complete to be published online by the administrator of Infect-ERA. The database is built on a search tool allowing a query by country, research topics, organism studied or/and methods-technologies. At the end of FP7 Infect-ERA project, 521 researchers were registered (http://www.infect-era.eu/public-partners).
A similar tool has been implemented to index the research infrastructures relevant to the ID community to promote the use of existing infrastructures and exchange of biological materials. The infrastructures have been mapped by Infect-ERA partners within countries participating to Infect-ERA JTCs and some of the JPI AMR countries not participating to Infect-ERA. About 700 infrastructures from 19 different countries have been mapped and published on the Infect-ERA website according to 21 different categories as for instance "animal model", "biobank", "cell culture" or "immunology" (http://www.infect-era.eu/infrastructures).

Other communication supports to ID community and general public:

In addition to using its website to inform the ID community, Infect-ERA was communicating about its activities via its social networks (Facebook and LinkedIn) and through at least the publication of two newsletters a year, which were sent to about 500 recipients. Communication to the general public about

the global challenges in the ID field have also been targeted by Infect-ERA. The Infect-ERA EAB has been filmed in a short movie explaining the challenges in ID and the objectives of the project Infect-ERA. In addition, two movies vulgarizing the herpes virus cycle and potential research to cure herpes as well as the human microbiome have been filmed and disseminated. Finally, all coordinators of projects funded through JTC1, JTC2 and JTC3 are explaining the objectives of their projects in separate short movies. Those movies can also be used by the coordinator to disseminate the topic of their research and increase the visibility of their projects as well as to attract new collaborators, academic or industrial. All movies produced by Infect-ERA have been published on Infect-ERA website and on YouTube.
Finally, three leaflets, targeted industry, scientists and the policy makers, pointing out the results and the expectations of Infect-ERA partners beyond Infect-ERA ERA-NET have been produced and disseminated.

Supporting the young scientists

Infect-ERA has performed different activities targeted to young scientists. First of all, different tools have been made available to support the development of their career. The training opportunities for PhD students and post-docs offered by some of the sister initiatives have been made available on the Infect-ERA web site (http://www.infect-era.eu/training) as well the main conferences in the ID field (http://www.infect-era.eu/conferences).

The first Infect-ERA video clip disseminated through YouTube and the Infect-ERA website draws attention to the current and global challenges in the ID field. Infect-ERA EAB members address the context, the needs and the aim of research in this area. The clip might give an orientation to the young scientists' interest towards this field of research. In a workshop (Vienna in May 2014), the EAB members addressed the need and shared their experiences with young scientists regarding the importance of networking activities in career development, the challenges of leading a group, how to start up a business, and how to protect the intellectual properties. A second workshop (Budapest in October 2015) was organised in four sessions: ID and opportunity, clinical aspects, funding and writing and joining industries. Young scientists involved in Infect-ERA projects were invited to this event, however, this networking meeting was opened to the whole community of young scientists working on human ID. Furthermore, young scientists funded through an Infect-ERA consortium (JTC1 and JTC2) were invited to participate to the INBIONET-Infect-ERA conference meeting (Belfast, September 2016) to establish a network between Infect-ERA and INBIONET fellows. Furthermore, the simultaneous organization of JTC1 final report and JTC2 midterm reports enabled the participant young scientists to meet each other, gather information about each others' and exchange ideas through the oral and poster presentations and networking sessions.

Finally, the development of funding measures to support early independence of young scientists was developed in JTC2, JTC3 and JTC4. A part of the available funding was dedicated especially to consortia led by young scientists. Each project leader of such consortia had to be a "young scientist", which was defined as having been awarded a PhD or equivalent at least two and a maximum of nine years before the deadline for submission of pre-proposals. A consortium of young scientists has been funded through JTC2 (CampyRNA). All young consortia received evaluation feedback that they can use to improve their research project and to submit it again to a future JTC or another programme.

Other funding programmes for young researchers have been listed during the mapping of funding programmes at the national and European levels and published on the Infect-ERA website (see section sharing the information with the ID community).

Infect-ERA long term cooperation framework concept

Developing a scientific strategy

Infect-ERA identified the best sustainable solutions for its future by identifying the best instrument for its collaboration and its scientific strategy. The scientific strategy has been determined with the help of Infect-ERA EAB. The EAB composed of 12 members coming from 11 European countries with clinical medicine, industry, and public health expertise, has been established at the beginning of Infect-ERA. The EAB role was to develop the scientific strategy of Infect-ERA and advice in optimizing Infect-ERA activities. The EAB identified research and funding gaps in order to adapt Infect-ERA JTCs to address the current challenges in human ID and also identified four particular themes of high importance to develop the future strategy of Infect-ERA. These themes are "host-pathogen relationships during onset and progression of infections", "human microbiota", "diagnostics and epidemiology" and "development of new treatments". The analysis of the strategic documents in ID available at the European level and the different topics funded by Infect-ERA partners at the national and European levels have also contributed to identify those themes. The EAB, with the help of additional scientists having an expertise more specific in the identified themes, wrote the Strategic Research and Innovation Agenda (SRIA) of Infect-ERA. Then, the SRIA has been shared with Infect-ERA partners, who were given the possibility to make a national consultation and agreed on its content. The Infect-ERA SRIA has been published in December 2016.
Infect-ERA has hired a subcontractor to perform a bibliometric study on the field of ID. The objectives were to analyse the scientific publications and patents in a period of five years in the 11 countries participating in Infect-ERA, in Europe and in the world. This allowed identifying the major topics of publications and patents as well as, the technical approaches used in the ID field. A detailed analysis will help Infect-ERA to define the scope of its future JTCs.
It is noteworthy that Infect-ERA partners envisage pursuing its collaboration beyond the Infect-ERA SRIA. As a first step, the Infect-ERA consortium wish to include HIV in the scope of Infect-ERA, which has been excluded until now, and thus invite the partners of the FP7 ERA-NET HIVERA, which was dedicated to HIV, to join the consortium. Finally, in light of the recent worldwide evolution of ID and epidemics, a final decision of Infect-ERA consortium was to broaden its scope to deeper the knowledge and surveillance of pathogens, their host, their vectors and their propagation in sort to anticipate new epidemics.

Strengthening the transnational collaboration

The bibliometric study commissioned by Infect-ERA has also allowed identifying the major actors in the ID field listing the nationality of the researchers, their institutions as well as their collaborations within and outside Europe. Over the period 2010-2014, the publications from European countries represent 28% of the global publications. Moreover, Infect-ERA countries have published a volume of 18 967 references representing 52% of the European volume of publications. The average of the

citations per publication is higher for the whole Europe than the Infect-ERA countries meaning that some European countries not represented in Infect-ERA consortium also have an important impact in the human ID field. Convincing these countries to be a part of Infect-ERA would help to pursue the efforts of Infect-ERA to coordinate and reduce the fragmentation of the research in this field with a higher impact. Through its JTCs, Infect-ERA has not only established long-lasting collaboration between the partners of its consortium but also with funding organisations not belonging to the Infect-ERA consortium. This was the case for the National Fund for Scientific Research (FNRS; Belgium), the research foundation Flanders (FWO; Belgium) and the Indian Department of Biotechnology (DBT; India), which participated in JTC2, JTC3 and JTC4. More recently, the Italian Ministry of Health (MoH; Italy) joined JTC3 and JTC4. Moreover, the Swedish Research Council (SRC; Sweden) has also participated in two Infect-ERA calls, JTC1 and JTC2. Some of these collaborators showed interest to become an Infect-ERA partner in a follow-up initiative. Moreover, Infect-ERA has been continuously communicating on its activity with additional countries e.g. Canada, Finland and the Netherlands.

Identification of a platform for Infect-ERA collaboration in the future

In parallel to the elaboration of the SRIA, a series of workshops has been organized to identify the best instrument that Infect-ERA partners could use to pursue their collaboration beyond Infect-ERA. For this purpose, Infect-ERA has collaborated with eight different sister initiatives coming from diverse horizons (Health, Social sciences and Technologies). The invited sister initiatives were using different instruments from the European Commission (EC) to collaborate as article 185, JPI, research infrastructure, a FP7 ERA-NET+ becoming an ERA-NET Cofund but also self-sustainable multilateral cooperation with different administrative operational architecture concepts and financial plans. Following those workshops, the Infect-ERA partners have been interviewed via a questionnaire at two different points of time to collect their vision on a possible future collaboration. The conclusion was that the preferred instrument of Infect-ERA partners was the ERA-NET Cofund due to the lack of resources of the funding organization allocated to the development of European collaboration. Only few partners were ready to go on a multilateral collaboration without the support of the EC, however, in a very restricted manner i.e. only by launching calls, which will generate a lower impact of the collaboration.

The bibliometric study allowed analysing the impact of the national, European and International collaborations by looking at the number of the citations obtained by those different classes of publications. Interestingly, the publications from at least one European country and one of the top-20 non EU countries authors show an impact of two to ten times more than a publication with only national authors. These data highlights the importance to join research efforts outside to the national borders to increase the visibility and impact of its research results in an initiative such as Infect-ERA. In addition, in 2014, 31 to 52% of the publications of Infect-ERA countries were the work from only national authors, 39 to 45 % of their publications were issues from collaborations between Europeans researchers and 10 % to 25 % of their publications were issues from collaborations between Europeans and International researchers. It is noteworthy that the international collaboration of European countries stays low. The ERA-NET Cofund is a good instrument to promote and to increase international collaboration within Europe. Since 2014, India represented by the Ministry of Science

and Technology Department of Biotechnologies (DBT) was participating to Infect-ERA JTCs. Noteworthy, it was the first participation of DBT to a thematic ERA-NET.

Implementation and monitoring of Infect-ERA activities

The assessment of the achievements of the Infect-ERA projects and its activities was performed in different steps: (i) to gather the partners' expectations relative to the Infect-ERA activities & objectives, and the national scientific community (ii) to identify indicators of performance in collaboration with Infect-ERA partners and EAB (iii) to use these indicators to evaluate the results of Infect-ERA and the last call of PGM and of Infect-ERA consortium. Most partners from Infect-ERA had very high expectations relative to the initiative. For the funding organizations their high expectations were related to the promotion of their funding organization at the international level and/or to the ambitious work described in the description of work. Another important outcome expected was the contribution to a more strategic international activity such as the delivery of a research agenda for the field of ID. Regarding their expectations for the scientific community, most partners pointed out the internationalization of their national scientific community and the increase of exposure and recognition on the national scientific level as a very important outcome of their participation in this network. For some partners, another important outcome is the positioning of their scientific community as European/International leaders in the field of ID. The results of a mid-term monitoring survey to Infect-ERA partners', using the defined indicators of performance, showed that Infect-ERA partners considered that the ERA-NET is producing "good" to "excellent" outcomes.
The results of the analysis of the indicators used to monitor the funded projects are presented in the section "Results of the funded research projects and networking".
In order to integrate lessons learnt from PGM into Infect-ERA activities, two questionnaires were developed and applied to PGM stakeholders i.e. 25 programme managers and 33 evaluators. Following the results of those questionnaires, Infect-ERA has implemented a major change on the procedure to monitor the funded projects. For example, in PGM, all partners of each consortium should report their scientific activity to PGM partners. In Infect-ERA, only a common report should be written by the coordinator. In addition, a similar exercise has been made at the end of Infect-ERA to monitor Infect-ERA activities. A questionnaire has been sent to the applicants of the four JTCs of Infect-ERA and to the evaluators. The following topics have been addressed: the dissemination of the Infect-ERA JTCs, the JTC topics, the call administration, the effect on international collaboration, the effect on economic exploitation and free comments. The responses of the Infect-ERA calls applicants and evaluators showed that dissemination of the calls is primarily by word of mouth, and the information provided by the pre-announcements was considered very useful by most respondents. The chosen call topics received good support, with the most of the answers suggesting the funding of fundamental research with broad topics or even open calls. Respondents indicated their satisfaction with the call documents, procedures and the support given by the secretariat and the national contact persons. Interestingly, some consortia have been contacted by companies for possible exploitation of the projects' outcomes. This consultation to the applicants validates the work performed in Infect-ERA and opens the door for improvement. The feedback from the enquired scientific community is that Infect-ERA provides unique funding opportunities for transnational consortia working on ID research and development. It has also confirmed the added value of the Infect-ERA programme as a funder of high quality

collaborative research in ID in Europe. The analysis also showed that Infect-ERA was very well embraced by the scientific community who expressed their wish for the programme to carry on. In conclusion, this study has provided to Infect-ERA partners with a better knowledge to support their decision to prepare a future collaborative initiative in the field of ID beyond Infect-ERA.

4 THE POTENTIAL IMPACT (INCLUDING THE SOCIO-ECONOMIC IMPACT AND THE WIDER SOCIETAL IMPLICATIONS OF THE PROJECT SO FAR) AND THE MAIN DISSEMINATION ACTIVITIES AND EXPLOITATION OF RESULTS (NOT EXCEEDING 10 PAGES).

4.1 Potential Impact

Contribution to the coordination of European research in infectious diseases

At the beginning of Infect-ERA, a mapping of the funding programmes able to fund human ID research was performed within the Infect-ERA partner' countries. The results showed only one partner had a national and specific programme, on "Microbiology, immunology, infectiology", at the national level. The other partners were all funding the ID research only by a bottom-up approach. This shows the necessity to have a top down programme, like Infect-ERA, at the European level to coordinate ID research to direct it to the research gaps and white spots.

Thus, Infect-ERA has fostered the network of national programme managers by widening the number of participants of the PGM consortium, which led to a wider impact of Infect-ERA activities and an improved the coordination of European research in ID. In addition to the 10 previous PGM partners from Austria, France, Germany, Hungary, Israel, Portugal and Spain, organizations from Belgium, Denmark, Poland, Romania and Spain have joined the consortium. Moreover, other funders from European and non-European countries joined JTCs launched by Infect-ERA i.e. funders from India, Italy, Sweden as well as two regional funding agencies from Belgium, which allowed the participation of Walloons and Flemish academic researchers to Infect-ERA JTCs.

Infect-ERA has launched four JTCs which created about 400 research investigator networks, who thought together about scientific problems in the ID field and established a plan of research to overcome this challenge. A survey answered by 371 applicants showed that 66 % of the respondents built their consortium in their first application on previous collaborations. These collaborations could had been established from previous collaborations with own funding, bilateral cooperation, EU framework programme or ERA-NETs consortia. However, in many cases, even if applicants have indicated that consortia were built on existing collaborations, new partners were added into the consortium to fulfil the gaps of expertise to perform the new project. New partners were found through participation in previous scientific conferences and meetings, but also through the database of researchers available on the Infect-ERA website. In the other cases, they were already acquaintances but had never collaborated.

Implementing four JTCs together, starting from the JTCs launch to the monitoring of funded project outcomes, had consequences for the alignment of processes, the timeline of JTCs and a common evaluation and monitoring procedures among 14 different countries. This alignment of processes

allowed the partners of Infect-ERA and further collaborators to gain a reciprocal knowledge and trust necessary to maintain a long-term cooperation. Furthermore, a common programme on ID followed in several countries avoided fragmentation of research in Europe in the ID field.

Thus, while building on the previous ERA-NET PGM, the Infect-ERA consortium further improved the linking, efficient integration and coordination of ID research to answer both, the increasing complexity and the upcoming challenges and changes in the field. In addition, Infect-ERA engaged its collaboration with new countries, on a European and International levels, envisaging an even wider coordination of the international ID research in the next phase of Infect-ERA collaboration.

Achieve critical mass and ensure a better use of limited resources in ID research

Infect-ERA also contributed to gather the different actors and combine the scarce resources to defy the ID challenges.

To develop biomarkers, preventive, diagnostic and therapeutic tools, fundamental research results should be brought into preclinical and first clinical studies. To this aim, it is necessary to facilitate cross-fertilisation between the different players (academia, clinic and industry) and to reach a critical mass of players at the European level. With the 14 European countries participating to Infect-ERA calls, the partners cover the possibility to fund academics, transnational and industrial research. Infect-ERA encouraged translational collaborations and gathered a sufficient number of players of all categories. In addition to encourage composing the consortia of academics and clinicians/industrial, "the prospects for the transfer of research project results into clinical and/or industrial" were an evaluation criterion.

Infect-ERA strategy to achieve critical mass also relies on the young researchers. To help young scientists developing their career, networking meetings with talks on different aspects on how to bring academics research to products were organized. These talks highlighted recent issues in clinical microbiology and public health with guidance on how to exploit the accumulated new knowledge in innovation, technology transfer and commercialization, illustrate the development of preventive and diagnostic measures and explain how to establish and maintain companies. Infect-ERA newsletters were also addressing these issues. In addition, to attract the new young researchers of the ID field EAB members explained the current challenges in a movie.

For a better use of the limited resources, Infect-ERA provided more visibility of national research infrastructures. Research Infrastructures have been mapped in the 11 Infect-ERA countries, Czech Republic, Italy and Netherlands, an associated country, Norway and two international countries, Argentina and India. They have been published in a search tool on the Infect-ERA website.

Infect-ERA facilitated the optimisation of the resources and achievement the critical mass via the funded research projects. This is reflected in creation of jobs and scientist training. At the mid-term stage of the projects, the eight projects funded through JTC1 have created 34 jobs including six fellowships. It can be excepted that this number will be comparable in the projects funded via the three other calls of Infect-ERA. The partners of the research consortia also mentioned in their applications that the international collaborative projects will bring the critical mass missing at the national level to achieve their project. In addition, an analysis of the outcomes of the PGM projects funded through the call in 2010 pointed out the importance of the exchange of young scientists for training in relevant techniques and exchanging protocols amongst all consortia. They were trained on procedures and

techniques as for example experiments with animal models, biofilm growth using microfermentors, genome sequencing, and techniques in microarray design as well as development and data analysis. Finally, like the PGM consortia, the Infect-ERA JTC1 consortia exchange bioresources. PGM consortia have exchanged reagents and biological materials – the funded consortia valued the opportunity to have access to strains and compounds which enriched and enlarged their libraries, promoting the expansion and growth of their research. In many cases the development and exchange of software and creation of websites, databases and technological platforms to exchange and publish information were also performed.

Promote transnational collaborations and generate new knowledge

Infect-ERA funded only transnational collaborations composed of researchers from at least three different countries. In the 34 Infect-ERA funded consortia, 66% display researchers from at least four different countries.

Young scientists had a unique opportunity to broaden their horizons and expand their technical and scientific skills by joining a network of top scientists in their respective fields. This allowed to train future researchers with a capacity for interdisciplinary thinking and awareness of the advantages of using various disciplines to achieve certain goals. The analysis of the outcomes of the last call of PGM (edition of 2010) showed that some of the students and post docs of the funded consortia obtained a specific training on procedures and techniques by another partner of the projects.

In addition, the programme PGM led to about 500 publications in international scientific journals, many of which with high impact factors such as Nature, PloS Pathogens, PNAS, Molecular Microbiology, PLoS Genetics, Journal of Bacteriology, BMC Microbiology, PLoS One and BMC Genomics. About 25% of the publications were published in a journal with an impact factor higher than five. Furthermore, the work developed in a few projects resulted in the submission of at least ten patents and also the creation of the spin-off company Peps4LS GmbH, from the project sncRNAomics.

Several projects funded under this programme brought significant advances towards the development of new therapeutics, diagnostics or vaccines for ID. In particular, some of these projects were focused on large screenings for the identification of new targets or new compounds for therapeutic uses; it was the case of the project RNAi-Net, which validated the use of a robotic screening unit for screenings with RNAi to identify novel targets and novel therapeutic options for high-risk pathogens. The project ANTIFUN improved drug-screening programmes by developing a high-throughput method and new drug combinations and hence contributing to new treatment strategies for invasive aspergillosis. In the project GeMoA, in combination with genome-wide approaches, screenings were made to characterize a compound library from the pharmaceutical company GlaxoSmithKline for its activity against *Mycobacterium tuberculosis*. From these studies, a novel compound with a new mode of action is under evaluation in terms of safety and advanced efficacy studies, which may constitute an important contribution to fight tuberculosis.

Other projects made relevant findings towards the identification of new drug targets and new diagnostic tools for different ID. This was the case of CHLAMYTRANS which was focused on chlamydial infections and PATHOMICS and developed novel biomarkers and drug target candidates for diagnosis and therapy of two classes of pathogens: *Chlamydia* and *Pseudomonas aeruginosa*. These pathogens cause infections with high incidence; the results of this project can lead to improvements in

their diagnostics and therapy. The project aspBIOmics developed a battery of in vitro assays for detection of *Aspergillus*. This has the potential to identify patients who are at highest risk of invasive aspergillosis (IA) before the infection occurs so that tailored prophylaxis can be given, and in patients who have established IA to monitor the success of antifungal therapy and the outcome of the infection. Another successful project was sncRNAomics which provided proof of principle for the use of modified peptide nucleic acids (PNAs) as therapeutics for Gram-positive pathogens to inactivate bacterial genes and sRNAs. The outcomes of this project led to the start of the spin-off Peps4LS GmbH. This small company specialized in small scale peptide and synthesis and parallel purification for the production of libraries and arrays and in the development of purification methods, drugs and diagnostic tools. Cellpath was also an ambitious project focused on the study of host signalling pathways and their alterations by one (or more) effector(s), with the aim to discover novel therapeutic approaches and to contribute for the design of vaccines and novel diagnostics. The study of the surface of fungal pathogens by the consortium of Glycoshield led to the identification of some proteins that can potentially lead to new vaccines. These are some clear examples of the important contribution of these projects and the impact of their outcomes on the improvement of prevention, diagnosis and control of ID.

At mid-stage of the Infect-ERA JTC1 and JTC2 funded projects, potential research and health impacts could have already been identified (see figure 2). Some projects allowed the generation of new animal models necessary to understand the host-pathogen interaction or which could be used for pre-clinical studies for new diagnostic tests, future therapies (antimicrobials or vaccines). Some projects allowed the identification of new species or strains, which are responsible for diseases of high importance. The consortia have also developed innovative screening systems to identify new targets to develop diagnostics tests or therapies. Finally, some projects are already identifying, characterising and validating new biomarkers or are developing innovative therapies (see figure 2). These data are only preliminary as in some of the projects, the development of potential diagnostic tests or therapies will be developed only in the second part of the project, after the identification of potential targets.

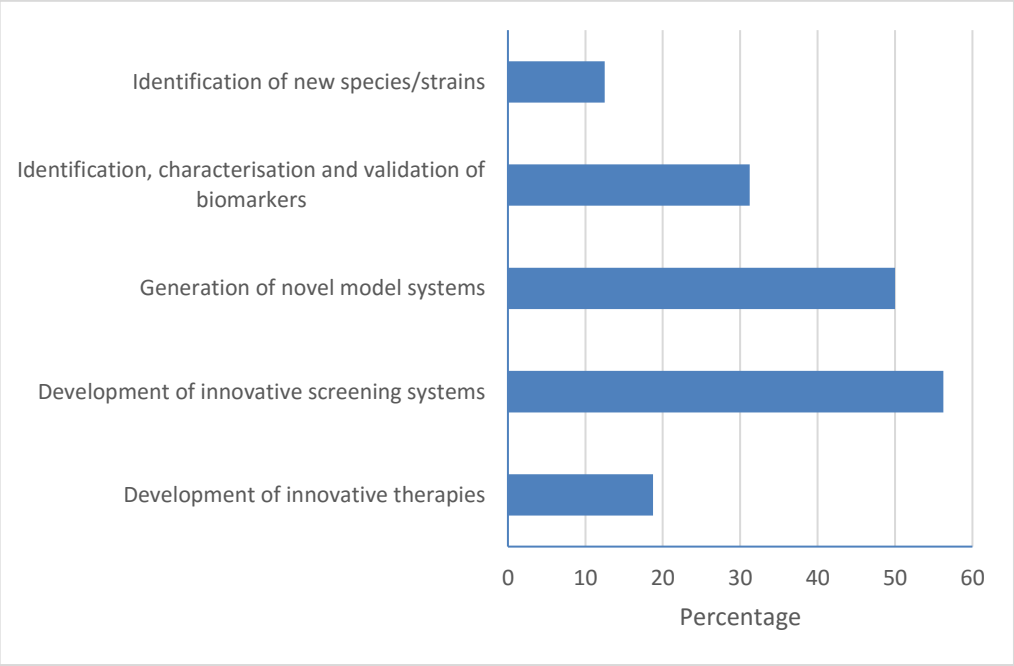

Figure 2: Potential research and health impacts of JTC1 and JTC2 funded projects through Infect-ERA

Contribution to strategic impact on human ID research

Infect-ERA has produced a policy document, a strategic research and innovation agenda (SRIA) in the ID field. To federate different European countries to the Infect-ERA SRIA, the SRIA has been produced by scientists from 12 different European countries. In addition, the SRIA has been proposed for validation to the 14 Infect-ERA partners. The SRIA described four current challenges in the human ID fields and the potential way to tackle those challenges with some recommendations. Those challenges are (i) the host-pathogen relationships during onset and progression of infections, (ii) the role of human microbiota in health and ID, (iii) advancing ID diagnostics and molecular epidemiology and (iv) the development of new treatments (see table 2).

Table 2: the challenges and subtopics identified in Infect-ERA SRIA

Host-pathogen relationships during onset and progression of infections
▸ Factors that influence host-pathogen interaction
▸ Personalized treatment
Role of human microbiota in health and infectious diseases
▸ Role of non-bacterial organisms in altering microbiota
▸ Gut is not the only affected system
▸ The effect of the host-microbiota metabolome on human health and disease
▸ Transition of microbiota from a commensal to a pathogenic state
Advancing Infectious Diseases Diagnostics and Molecular Epidemiology
▸ Bringing infectious diseases diagnostics closer to the patient at the general practitioner's
▸ Focusing on pathogen sub-typing for detection of high-risk clones in various infectious diseases of innovative strategies for the diagnostic and treatment of high clinically relevant microbial infections; optimisation of antimicrobial therapy in an individual patient and development of biomarkers to allow individual response prediction
Development of new treatments
▸ Novel and experimental therapies to fight against emerging microbial challenges, either due to bacteria, viruses, fungi, parasites, and their vectors
▸ New antivirals to fight emerging and re-emerging viral infections
▸ Therapy of the pathogenic host response to the microbial challenge

4.2 The address of the project public website, if applicable as well as relevant contact details.

http://www.infect-era.eu/

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General Video clips on ID produced by Infect-ERA:

- Translational Research on Human ID:

https://www.youtube.com/watch?v=bWNtCFFZibk

- Herpes Cure: How close are we?

https://www.youtube.com/watch?v=zdUDsWKqyik&feature=youtu.be

- Human Microbiome:

https://www.youtube.com/watch?v=y4ZCa34biJ8&feature=youtu.be

Short video clips on Infect-ERA funded projects:

- JTC1:

AspMetNet https://www.youtube.com/watch?v=0VQWtLw0074&feature=youtu.be
PROANTILIS https://www.youtube.com/watch?v=IVgvpcJyG6M&feature=youtu.be
Haplo-Infect https://www.youtube.com/watch?v=cKjngi1wpdE&feature=youtu.be
HCV-ASSEMBLY https://www.youtube.com/watch?v=ygIzTjfDfwI&feature=youtu.be
Abir https://www.youtube.com/watch?v=CHiX2YxKeYQ&feature=youtu.be
hepBccc https://www.youtube.com/watch?v=Squ4lTvAyLw&feature=youtu.be
CINOCA https://www.youtube.com/watch?v=YnUa4rrD5-E&feature=youtu.be
EUGENPATH https://www.youtube.com/watch?v=wKnpEbOR3CY&feature=youtu.be

- JTC2:

FunComPath https://youtu.be/gFKr-wPN39I
ESCential https://youtu.be/wib-8wnkl04
CampyRNA https://youtu.be/XdHAoeBSzu0
AMOEBAC https://youtu.be/df9qc3s1GO0
eDEVILLI https://youtu.be/tgX1I4Ys_yw
BactInfectERA https://youtu.be/NNFlPfMsrT4

ERASE https://youtu.be/FDyoSDNgGLM
The nice bug https://youtu.be/P-gzRVEO8O8

- JTC3:

BU_SPONT_HEAL https://www.youtube.com/watch?v=kjODXmvyaJs
CryptoVIEW https://www.youtube.com/watch?v=OUP8nw43KlU
FloraStopMRE https://www.youtube.com/watch?v=3UufafjFNTs
HantaHunt https://www.youtube.com/watch?v=h6AdRMumRIg&t=31s
HPV-MOTIVA https://www.youtube.com/watch?v=M-Cjm5tiXzE
Sal host trop https://www.youtube.com/watch?v=Q81gDC1V7rk
SRecognite https://www.youtube.com/watch?v=5sXJpcg1c-0
StaphIN https://www.youtube.com/watch?v=ikyd7rWa7W4
TANKACY https://www.youtube.com/watch?v=gh0M9j6le58

4.3 Use and dissemination of foreground

Project results	Purpose(s)	Dissemination and Communication tools	Target population
Infect-ERA funded projects	• Increase knowledge and understanding of (funding) research on ID • Bring the projects results further in the innovation chain • Awareness on Infect-ERA	• Kick off meetings • Newsletters • Infect-ERA web site • Leaflet • Video clips • Social Networks	• Infect-ERA EAB members • ID scientific community • Industry • Programme Owners • Programme Managers
Catalogue of funding programmes	• Optimsing the available resources in the ID field • Providing additional funding oppotunities for the researchers in the ID field • Awareness on Infect-ERA	• Presentation at the EAB workshops Presentation at Kick off meeting and mid-term status seminars • Presentation at the stakeholder and sister initiatives workshops • Presentation at the Infect-ERA evaluation meetings • Infect-ERA web site • Newsletters • Social Networks	• ID scientific community • Sisters initiatives • Programme Owners • Programme Managers
Search tool to identify a research infrastrucutre	• Better use of limited ressources • Awareness on Infect-ERA	• Presentation at the EAB workshops • Presentation at Kick off meetings and mid-term status seminars • Presentation at the stakeholder and sister initiatives workshops • Presentation at the Infect-ERA evaluation meetings • Infect-ERA web site • Newsletters • Social Networks	• ID scientific community • Sisters initiatives • Programme Owners • Programme Managers

Search tool for collaboration	• Increase the collaboration in the ID field• Awareness on Infect-ERA	• Presentation at the EAB workshops• Presentation at Kick off meeting and mid-term status seminars• Presentation at the stakeholder and sister initiatives workshops• Presentation at the Infect-ERA evaluation meetings• Infect-ERA call texts• Leaflet• E-mails/Letter• Infect-ERA web site• Newsletters	• ID scientific community• Industry
The strategic research and innovation agenda	• Develop a scientific strategy for Infect-ERA • Awareness on Infect-ERA	• Infect-ERA web site • Newsletters • E-mails • Social Networks	• ID scientific community • Industry • Programme Owners • Programme Managers
Support the development of the young scientists career	• Achieve a critical mass • Awareness on Infect-ERA	• Presentation at the EAB workshops • Presentation at Kick off meeting and mid-term status seminars • Presentation at the stakeholder and sister initiatives workshops • Presentation at the Infect-ERA evaluation meetings • Infect-ERA call texts • E-mails/Letter • Infect-ERA web site • Newsletters • Social Networks	• ID scientific community
Infect-ERA long term cooperation framework concept	• Strengthen Infect-ERA consortium • Awareness on Infect-ERA	• E-mails/Letter • Leaflet	• Programme Owners • Programme Managers