



JRC TECHNICAL REPORTS

Monitoring and Assessment Framework for the European Innovation Partnership on Active and Healthy Ageing (MAFEIP)

Gap Analysis

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2016

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JRC101550

EUR 27936 EN

ISBN 978-92-79-58535-7 (PDF)

ISSN 1831-9424 (online)

doi:10.2791/733459 (online)

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How to cite: Christian Boehler, Fabienne Abadie (2016) 'Monitoring and Assessment Framework for the European Innovation Partnership on Active and Healthy Ageing (MAFEIP). Gap Analysis'. Institute for Prospective Technological Studies. JRC Technical Report EUR 27936 EN; doi:10.2791/733459

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Abstract

DG JRC-IPTS has been developing a Monitoring and Assessment Framework to assess the health and economic impact of the activities carried out by stakeholders of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA) within the MAFEIP project. In this context, IPTS has conceptualised a decision analytic model which has been implemented as a web-based tool, the MAFEIP tool. This tool builds up from a variety of surrogate endpoints commonly used across the diverse set of EIP on AHA commitments in order to estimate health and economic outcomes of the Partnership. Stakeholders can access the tool through an intuitive web-based user interface that is linked to a database of country, age and gender specific mortality data.

This report offers a review of the issues encountered with the set-up of the model, the usability of the tool, technical issues and further gaps that could be identified in the course of the tool implementation as well as issues related to data collection. It offers recommendations as to what improvements could be undertaken in the future.

Major tool developments to be considered aim at improving its flexibility and ability to be adapted to different contexts through, for instance: the optional inclusion of additional health states in the model; the ability to insert more nuanced data for model parameters; enabling explicit assessment of heterogeneity amongst patients; and also allowing for (selected) multivariate sensitivity analysis. However, whilst each of these potential tool improvements has the ability to increase its flexibility and enable better adaptation to various interventions, patients, and care contexts within the EIP on AHA, they all increase complexity, which in turn impacts the amount of data required and the experience needed.

Finally, the EC should invest in activities to raise awareness of the added- value of the MAFEIP tool for EIP on AHA stakeholders (and potentially beyond) in order to foster its uptake, improve expertise within the EIP on AHA through seminars and workshops, and build up an evidence base for MAFEIP through the conduct of additional case studies.

1. Introduction

Through the MAFEIP project, DG JRC-IPTS has been developing a Monitoring and Assessment Framework to assess the health and economic impact of the activities carried out by stakeholders of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA). To allow for such monitoring, IPTS has conceptualised a decision analytic model which has been implemented as a web-based tool, the MAFEIP tool [1, 2].

More specifically the MAFEIP tool, which links an intuitive, web-based user interface to a generic three-state Markov model and a database of age, gender and country specific baseline mortality data [3], allows EIP on AHA stakeholders to estimate the impact of their activities on a) quality adjusted life years (QALYs), which combine information on life expectancy with health related quality of life as well as b) the sustainability of health and care systems in terms of the incremental impact of interventions on health and care expenditure. Users can adapt the tool to their respective interventions and care contexts through remote data entry [2].

The MAFEIP tool builds up from a set of outcome indicators previously identified by JRC-IPTS as highly relevant across EIP on AHA commitments and Action Groups [4, 5]. Indeed, based on the analysis of several data sources related to the activities of the EIP on AHA Action Groups, IPTS first identified a number of potentially relevant outcome indicators and then assessed their ability to be linked to the EIP on AHA objectives [4]. The resulting long list of potential indicators was then further refined through a survey on outcome indicators used by EIP on AHA stakeholders [5]. As a result, a short list of potential outcome indicators for the quantitative monitoring of the EIP on AHA could be defined [5].

By taking into account aspects of linking outcome indicators to improved health status/ health related quality of life, and the sustainability of health and care systems, a distinction could be made between a set of "primary" and "secondary" outcome indicators [4]. Primary outcome indicators are not only generic and therefore relevant across a number of commitments and Action Groups, but also particularly well suited to establish a quantitative link to the EIP on AHA targets. Secondary outcome indicators may be more 'surrogate' in nature and therefore rather relevant for specific Action Groups within the EIP on AHA, and they may also require linkage to primary outcome indicators first in order to allow modelling the impact on the EIP on AHA targets [4].

The three generic health states of the MAFEIP model (baseline health, deteriorated health, death), which runs in the background of the MAFEIP web-tool, can be applied by EIP on AHA stakeholders to their particular interventions, populations and care contexts by inserting data for parameters which can relate to various outcome indicators as previously identified. Baseline mortality data, stratified by age and gender for each member country, is already provided by the tool [3], and can be further adjusted to respective target populations through inserting relative risks through the user interface, whilst all other parameters (incidence, health state utilities and resources use) should also be provided by its users. This way, the MAFEIP-tool can be used to estimate the change in quality adjusted life expectancy related to the activities carried out in the EIP on AHA and the estimated impact of a social or technological innovation on health and social care expenditure in a particular context.

Ultimately, this allows not just monitoring the impact of the EIP on AHA towards its overall objectives, which was the original aim of the MAFEIP project, but it enables stakeholders of the Partnership to perform an early and iterative assessment of innovations' cost-effectiveness at various stages of the development process [2]. With this information, the MAFEIP-tool can be useful for assessing the potential of a new technology, which is important information for developers to decide upon further design, investment, and evaluation; and the EIP on AHA to provide appropriate support for

innovations to facilitate faster progress to the next stage of development and/or implementation.

This report offers a review of the issues encountered with the set-up of the model, the usability of the tool, technical issues and further gaps that could be identified in the course of the tool implementation as well as issues related to data collection. It offers recommendations as to what improvements could be undertaken in the future.

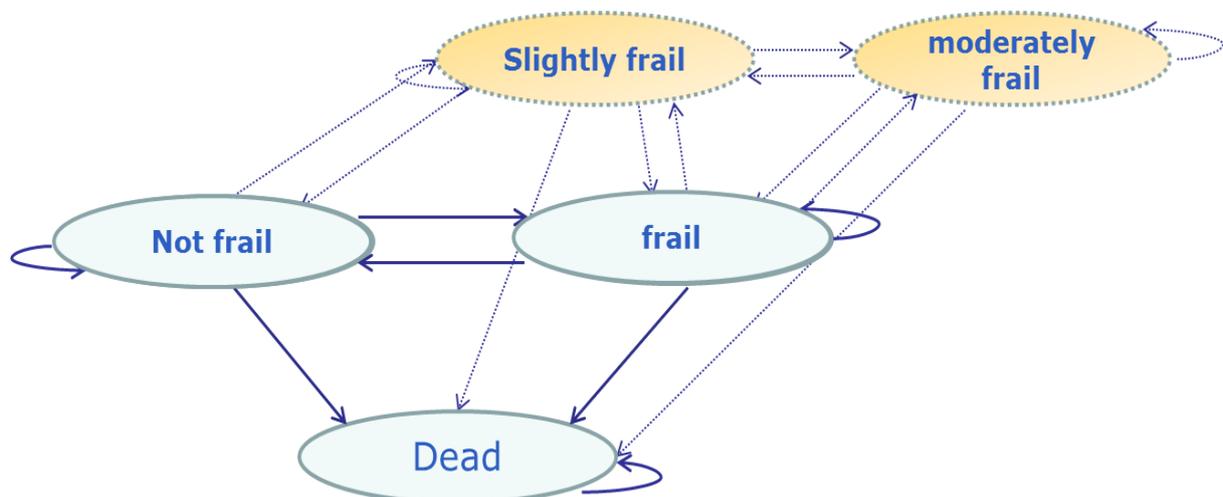
2. Tool and model set-up

2.1 Optional inclusion of additional health states

The aim of the MAFEIP tool and its underlying model is to balance the trade-off between a high level of flexibility to allow adaptation to various contexts combined with a (relatively) low level of complexity to enable usage by inexperienced users and/or in the light of scarce and scattered data to populate the tool. Indeed, ensuring adaptation to a wide array of different interventions whilst enabling non-experts to make use of the tool led to the decision to restrict the Markov-model to three health states, with two 'alive' states ('baseline health' and 'deteriorated health') and the absorbing 'dead' state. The basic idea is that users can define the two 'alive' states in such a way that they represent the state of the population that receives the intervention and the condition that the intervention aims to prevent, improve or achieve.

Although it is possible to model many interventions using a three state model, the optimal number of states depends greatly on the specific intervention, context, and availability of data. Data availability, in turn, depends in many cases on the definition of health states in epidemiological studies and trials. Indeed, one case study carried out in order to test the MAFEIP-tool in the context of mobile monitoring and training for frailty clearly showed that a model with more than three health states would have been preferable given the data collected in a trial conducted by the respective EIP on AHA commitment. As a consequence, in order to fit the data into the existing tool, it was necessary to define health states in the model differently from how it was done in the trial, which was clearly not optimal in terms of estimating the potential health and economic impact of this intervention. A tool which provides the option to its users to add additional health states to its basic three-state model would have allowed better adaptation to this case and therefore improved the flexibility of the tool significantly (Figure 1).

Figure 1: MAFEIP-model with optional inclusion of additional health states



On the other hand, expanding the model with more states substantially increases the complexity of both the model and the tool as the definition of a set of mutually exclusive states becomes more complicated and the number of possible transitions (represented by arrows in Figure 1) increases exponentially with the number of states in the model. This means that increasing the number of states also substantially increases the need for data. However, due to the early stages of many innovations within the EIP on AHA, it

may be rather unlikely that a large number of commitments would be able to provide the data required to populate models with more states.

Two additional constraints exist a) with respect to the expertise required to populate even more complex models and b) the availability of software for decision analytic modelling. It is arguable that the current version of the tool, though developed with rather inexperienced users in mind, will already require additional support in order to enable EIP on AHA stakeholders to make the best use of it. Further health states, as mentioned above, increase the complexity of the model and the majority of inexperienced users amongst EIP on AHA participants may not be able to handle such a tool efficiently without extensive user support. On the other hand, those EIP on AHA participants who may have sufficient expertise in handling more complex models, may opt for available expert tools for decision analytic modelling, or build a bespoke model in MS Excel or other suitable software as this provides additional degrees of freedom to the modeller.

In conclusion, whilst developing the tool further through the optional inclusion of additional health states does provide an added benefit in terms of flexibility and the ability to adapt the tool to different contexts, this needs to be balanced against the constraints in terms of data availability and experience of users, and also against the significant additional resources required to develop the MAFEIP tool further in this direction. Generally, expanding the model beyond three states implies constructing a Markov-model and a user interface which are flexible with respect to the number of states, and this could result in a challenging and resource intensive task. A potentially feasible strategy has been implemented previously through the MATCH-tool, another web-based decision support tool based on a Markov-process [6]. This tool requires its users, upfront, to select between two and five states for which to populate the model. Depending on the selection made, users are then being referred to the respective data input sheets which are linked to the appropriate model in the background. Neither model nor user interface need to be flexible with respect to the choice of number of health states, as all respective versions exist in parallel. Nevertheless, substantial efforts would be necessary to develop the MAFEIP tool further into this direction.

2.2 Specifying starting health states

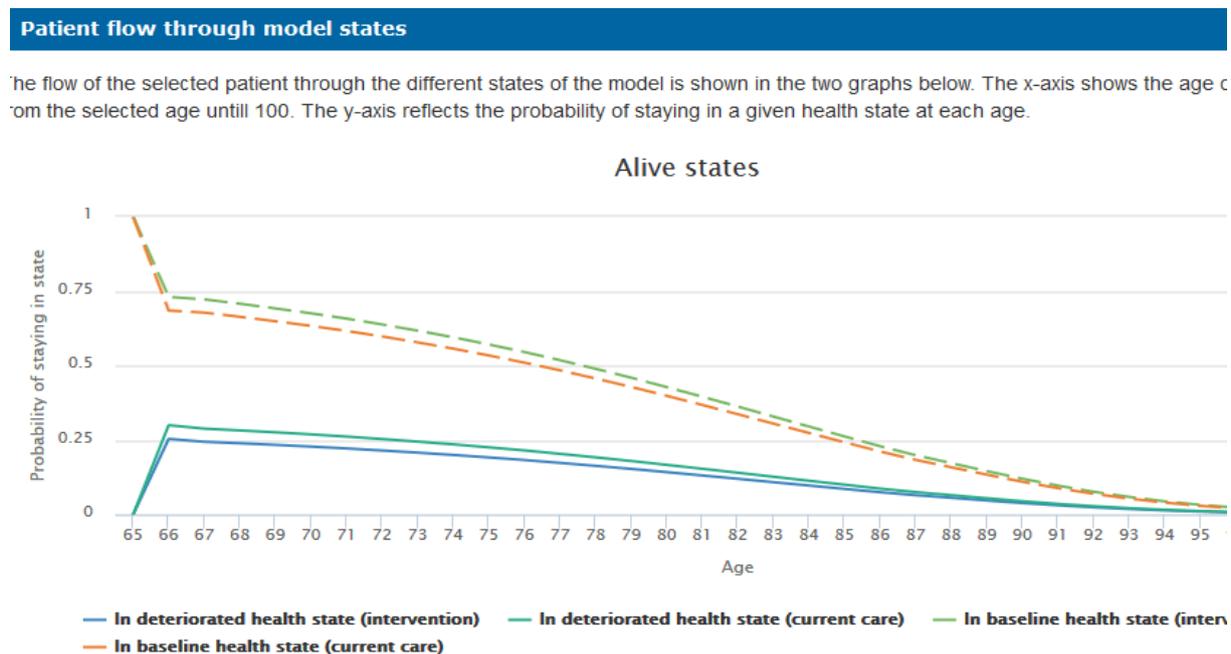
In the current version of the tool, individuals start the simulation, per default, in the baseline health state and they may then transition into a state which is labelled as 'deteriorated health', or into the 'dead' state respectively. This implies that the baseline situation should always be one of better health and that individuals always transition into a state of reduced health. As the tool actually also allows modelling interventions which target individuals in a less preferable health state at baseline in order to improve their health status, few small changes to the way the tool is currently being set up could significantly improve its intuitiveness and flexibility.

First, giving users the option to label the two alive states themselves would be a simple improvement that would make the tool more intuitive, especially when interventions aim to improve the health status of individuals who are in a less preferable health state at baseline. Even though individuals start, per default, at the baseline state and the current labelling of health states refers to a worsening of health status, it is nevertheless possible to model an intervention improving the health status in the current version of the tool. All that needs to be done is to assign health state utility weights, resource weights (and perhaps relative risks for mortality) to the deteriorated health state which represents a preferable situation compared to baseline. This, however, may be counterintuitive to some users, especially if they have little experience in decision analytic modelling. Adapting the user interface in a way that users can label their respective health states would therefore be a simple but useful improvement.

Secondly, there are situations in which it could be useful to specify the distribution of patients over the starting states, in other words, enabling to model a mixed starting

population with some individuals in the baseline health state and some in the deteriorated health state at year one of the simulation respectively. One such situation in which this became particularly apparent was in the MAFEIP case study related to an early innovation to predict falls among older people. In this case study, the three state model was adapted in a way that baseline represented the state before a fall occurred, and deteriorated health represented the state after a fall had happened. The transition between both health states therefore represented the annual probability of a fall in a general population between 65 and 84 years in England and Wales. However, as all individuals started, by default, in the baseline health state in the first year of the simulation, the model essentially assumed that no falls happened during year one and it only reached a 'steady state' after the first cycle. This is also documented by the sudden leap / drop in patient flow through alive states of the model after year one of the simulation in Figure 2.

Figure 2: Patient flow through model states in 'falls-prediction' case study



Whilst individuals face a probability to fall already in the first year (i.e. to transition from baseline to deteriorated), this cannot be reflected in the tool without specifying a mixed starting population with some individuals starting the simulation from the baseline health state and others from the deteriorated health state respectively. This could be further useful in situations where an intervention is both preventive as well as curative and provided to both patient groups. Taking this concept one step further, it can also be used to specify a relation between age and the probability of starting the simulation in either of the health states.

2.3 One-off costs and annual costs of current care

Another simple and useful tool development could be to allow users to explicitly specify one-off and annual costs per patient not only for the intervention under assessment, but also for the respective standard care scenario.

Cost items to be considered for the intervention include a) one-off intervention costs and b) total intervention costs per person per year. One-off intervention costs represent the total costs incurred only once per patient (e.g. the cost of a surgical procedure that happens only once for each patient in the intervention cohort or the per patient amount corresponding to the costs of implementing the service). The total intervention cost per

person per year consists of two components: first, the variable costs of the intervention are incurred for each individual and each year and represent, for instance, the annual costs for medication, personal devices or delivery of the intervention. Second, the share of annual fixed costs per patient currently treated or targeted by the intervention represents, for instance, the annual cost of the infrastructure used for all patients divided by the number of patients currently treated or targeted by the intervention. Currently, the tool allows users to explicitly specify these costs for the intervention only (Figure 3).

Figure 3: One-off and annual intervention costs considered by the MAFEIP tool

Costs

The costs associated with each state of the model for both the intervention and the standard care scenario should be provided here.

Intervention costs

Cost items to be considered for the intervention include a) one-off intervention cost and b) total intervention cost per person per year. Intervention cost represent the total cost incurred only once per patient (e.g. the cost of a surgical procedure that happens only once per patient in the intervention cohort or the per patient amount of implementation cost of the service). The total intervention cost per person per year consists of two components: First, variable cost of the intervention are incurred for each individual and each year and represent, for instance, the annual costs for medication, personal devices or delivery of the intervention. Second, the share of annual fixed costs per patient currently treated or targeted by the intervention represents, for instance, the annual cost of the infrastructure used for all patients divided by the number of patients currently treated or targeted by the intervention.

One-off intervention costs ⓘ	€ 0
Intervention costs per person per year ⓘ	€ 130

This set-up allows modelling the impact of innovations where all current care costs are reflected exclusively through health state resource weights and only for the intervention users have the option to define, explicitly, one-off costs or annual per-patient costs for each model cycle. Hence, the tool is very well suited for situations in which an innovation *adds* to existing care pathways but does not intend to *replace* the current care scenario. Also, in the current tool set-up it is possible for the user to explicitly account for one-off costs as well as annual costs per patient for the current care scenario, but only as long as the intervention incurs *higher* one-off costs and annual costs per patient compared to current care. In this case, users should insert the *incremental* one-off intervention costs as well as the *incremental* intervention costs per person per year in the respective fields provided by the tool, but also make sure that these costs are deducted from health state costs for current care in order to avoid double counting.

However, what if an intervention could potentially replace an existing technology which is characterised by higher one-off costs as well as higher per patient costs per year? This would result in negative incremental values for intervention costs, which the tool does not allow inputting. Hence, in the current set-up, this situation could only be reflected through differential health state costs between standard care and intervention scenario. A more intuitive solution would be, however, to allow users to insert one-off and annual costs per patient for both the intervention and the standard care scenario.

2.4 Modelling heterogeneity

The current version of the tool makes use of mortality and population size data from the Human Mortality Database. Users can adjust this data through the interface which will then modify the selection of age, gender and country-specific mortality from the database. Further customisation is possible by entering relative risks, however, as for all other parameters of the model, these are not age or gender-specific.

Although heterogeneity may also be analysed by increasing the number of states (as discussed in section 2.1 above), or by running the model several times for different subgroups, incorporating heterogeneity into the tool would be a useful improvement. As a first step, the tool could be developed further by allowing users to explicitly define age/cycle-dependent transition probabilities between health states. This includes transition probabilities between both alive states of the model, and also transition probabilities from alive states into the dead state as risk ratios to adjust mortalities may not always be available or appropriate. In addition if the user is trying to model a subgroup of the population, background data may require further adjustment. It would therefore be useful if the model user could fill in age/cycle dependant transition probabilities, which in the case of mortality data would then overwrite the background information given by the model.

Besides transition probabilities, it is also likely that health state weights (health state utilities and resource weights) depend on age and gender, so that allowing users to insert more nuanced data would be a further improvement.

In addition to age and gender, users could also be allowed in the future to model heterogeneity with respect to other subgroups, for instance related to risk factors such as BMI or smoking, or physical characteristics such as disease severity or comorbidities. This could be achieved within the tool through the possibility of defining subgroups within the cohort, each with their own sets of parameter estimates, or modifiers compared to the baseline cohort.

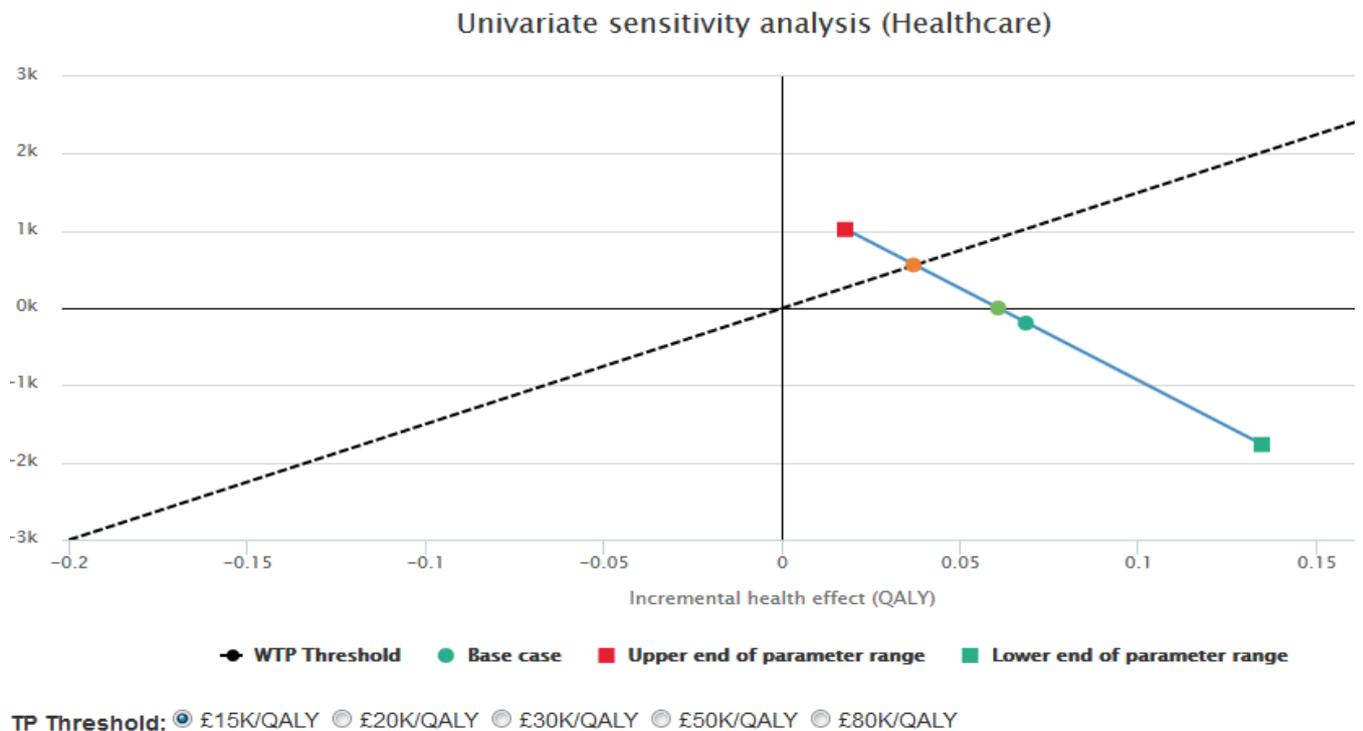
However, in all of this, a balance needs to be maintained between complexity and accuracy. As with the optional inclusion of additional health states, the resulting tool would become significantly more complex, and in order to utilise different options to model heterogeneity, users would have to have the respective estimates to populate parameters with data. For a large number of commitments and innovations developed within the EIP on AHA, the additional data requirements and/or the additional complexity of the resulting tool could be prohibitive for making efficient use of it. Certainly, more experienced users would prefer to be able to change *everything* in the tool, something which could be overwhelming for less experienced users. The latter, who may constitute a majority amongst potential users within the EIP on AHA may prefer to use a tool that is less complex even if this implies less accuracy. Therefore, as with the number of model states, the resources required to develop the tool further into this direction need to be weighed against the additional benefits resulting from improved tool-capacities for modelling heterogeneity within the target cohort.

2.5 Sensitivity analysis

In order to foster the uptake and use of the MAFEIP tool by EIP on AHA stakeholders, it was conceptualised in a way that would hopefully provide users with an added benefit, rather than just adding to the burden of data collection within the Partnership. For this reason, we developed the MAFEIP tool so that it would not only enable monitoring the impact of the EIP on AHA towards its overall objectives, which was the main aim of the MAFEIP project, but to enable stakeholders of the Partnership to perform an early and iterative assessment of innovations' cost-effectiveness at various stages of the development process. A crucial feature to enable such an assessment is the ability to perform sensitivity analysis. As many of the innovations developed and implemented within the EIP on AHA are still in early stages, data is typically scarce and scattered, and in many cases, robust information, for instance about effectiveness or resource use, is not yet available for the technology under assessment. The analysis of a new technology should, in such a situation, focus on aspects such as defining broad mechanisms of impact, how care is currently specified and in which way the technology is likely to change this, and how to quantify impact of the technology with the best evidence that is currently available. This should result in a better understanding of the conditions under which an innovation may be worth further development, investment and/or evaluation, and the model parameters that have the biggest influence on these conditions.

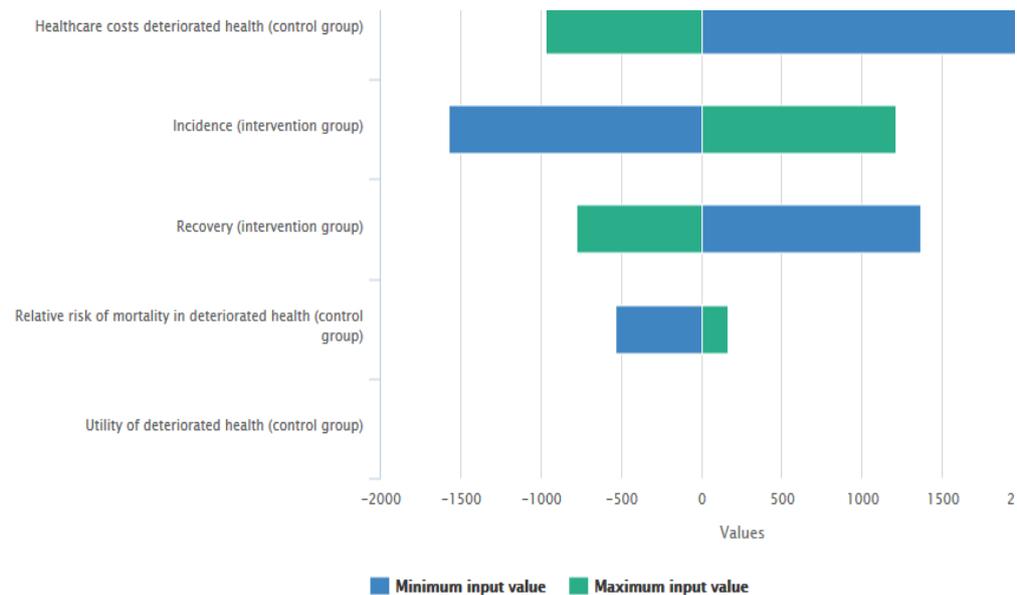
The current version of the tool provides several options for performing univariate sensitivity analysis of model parameters, and a probabilistic module may become accessible upon request in the future. Univariate sensitivity analysis allows assessing the impact of changing each parameter of the tool on model outcomes.

Figure 4: One way sensitivity analysis – cost-effectiveness plane



For instance, the cost-effectiveness plane displayed in Figure 4 allows choosing, one at a time, the parameters that the user would like to analyse. It shows how the range that the user previously specified for this parameter compares to the base case outcome in incremental terms. By selecting a willingness to pay (WTP) per QALY threshold, the user can see whether certain input values lead to incremental cost and effect combinations above or below this threshold. On the other hand, the Tornado diagram displayed in Figure 5 summarises the impact of a change in each parameter on the incremental cost of an intervention relative to the base case scenario. The parameter leading to the highest change in incremental costs is displayed at the top of the diagram, followed by the parameter leading to the second highest change in incremental cost, and so on and so forth. Ordering parameters from the one having most impact to the one with least impact on incremental costs leads to the characteristic tornado-shape of the diagram.

Figure 5: One way sensitivity analysis – Tornado diagram for incremental costs



Whilst the tool in its current version allows for univariate sensitivity analysis as described above (and also probabilistic sensitivity analysis upon request), it does not, however, allow varying multiple parameters of the model simultaneously in a multivariate sensitivity analysis. This could be a limitation in situations where the impact of an intervention relates to several model parameters simultaneously. For instance, the effectiveness of an intervention could impact simultaneously on the transition between both alive states (incidence and recovery), their resource use and utility weights, as well as mortality, so that analysing different levels of intervention effectiveness would ideally be done by altering these parameters simultaneously. Likewise, there could be different specifications of the current care scenario against which the intervention is being compared, and the transition probabilities under current care conditions are not always known. The intervention effect (here the incidence for the intervention alternative) would be defined relative to the current care incidence, and such links between several parameters cannot be assessed with the current tool.

Developing the MAFEIP tool further in order to enable users to perform multivariate sensitivity analysis would ultimately require a set-up that allows assessing all possible combinations of parameters in the model (both within and between intervention and standard care scenario). This would result in a vast number of potential parameter combinations to consider which would most certainly be prohibitive both in terms of model and interface development and the resulting complexity for the end-user. A more feasible solution would be to pre-specify a limited number of *common* parameter combinations and provide the option to assess those pre-defined elements within the tool. Although this solution would be less flexible, as some combinations provided by the tool may not make sense in each context, and others that could be useful in a certain context may not be provided by the tool, it would still allow for some multivariate analyses whilst reducing the additional complexity in terms of both developing and using the tool to a more reasonable level.

3. Technical issues

When it comes to technical issues, it is important to note that the current version of the MAFEIP tool, which DG JRC IPTS developed together with external contractors, is a prototype. Despite our utmost efforts to test and improve the tool before launching it, including through internal and external validation, the conduct of several case studies and consultation with experts, DG JRC IPTS cannot exclude the possibility of remaining errors that could impact on the performance or results of the tool. This section summarises some of the main issues that may require further attention for the future development of the MAFEIP tool.

3.1 Managing concurrent model sessions

One of the most important challenges throughout the tool development process was to ensure that a number of concurrent model sessions can take place once the MAFEIP tool has been rolled out to the public. Whilst for the deterministic version of the tool this may be of rather theoretical relevance (because of a model run-time below 10 seconds), it constitutes a realistic problem for the probabilistic module which takes much more time to run. A probabilistic analysis within the MAFEIP tool requires repeating, up to a maximum of 1000 times, the simulation carried out by the model, each time taking randomly values from a distribution specified for each model parameter. The model run time in the probabilistic mode can easily take more than five minutes, so that in order to protect IPTS servers, only very few sessions can run concurrently.

As a first step, it was therefore decided to limit access to the probabilistic module to few individuals within IPTS only. Users may contact IPTS in the future to obtain time restricted access to the probabilistic version upon request (see section 3.3 below). However, it was still necessary to find a solution to ensure several model sessions could run in parallel, without causing a system overload. Currently, 2 CPUs are assigned to the MAFEIP model and with 7 minutes for the longest model run, in theory, it would not be possible to run more than 3 probabilistic models in parallel with the expectation to return within 10 minutes of http timeout (which is already twice the standard default).

The optimal solution to this problem would be to put concurrent sessions into a chain and process them consecutively; however, despite our request, the contractor in charge of writing the code for the MAFEIP tool was not able to implement such a chain management for concurrent sessions. As an alternative solution, a counter was implemented for concurrent sessions with a fixed limit. Once the limit is reached, users are shown a warning stating that the maximum number of concurrent sessions has been reached. Users may then return to the tool once the counter drops again beneath the limit, which is currently set at 5 sessions.

After implementing this alternative solution, problems continued as testing showed that the counter would, in some specific situations, not drop back beneath the limit even after model sessions had ended, so that the tool needs manual unblocking through the administrator. Though we continued working with the contractor to resolve this issue, only practice testing after public rollout can show whether this may still constitute a real problem. However, as mentioned before, for the deterministic module, which is the only one being rolled out to the public at this stage, this issue may only be of theoretical relevance, and for the probabilistic tool, access is currently limited and only available upon request. In other words users should not be affected by the concurrent sessions problems as long as the use of the probabilistic version is restricted to IPTS and those users who request a session.

In the long run, however, it will be necessary to reconsider the current solution to the concurrent session problem. As a first step, close attention should be paid to the number of occasions when, for instance, both CPUs assigned to the tool are in use for more than 5 minutes, and based on this, a decision should be made with respect to implementing a more stable solution to the problem.

3.2 Further improvements to the user interface

The user interface has been developed with rather inexperienced users in mind and in the most user-friendly way possible, given the limited time and resources available for tool development. Indeed, at the start of the MAFEIP project, the idea had been to develop a very basic Excel-based toolkit. The MAFEIP tool, which is now available online and which allows users to carry out their own analyses, is much more powerful and user-friendly than an Excel-based toolkit. Users are guided through the process of data entry, results, and various options for sensitivity analysis (as described above), and the interface offers plenty of background information, links to additional resources, and mouse-overs with additional explanations.

Although we aimed to develop the tool interface in an intuitive and user-friendly fashion, the overall functionality of the user interface could be revised in the future with a view to improving the user experience further. For instance, the way sections open and close could be made slightly more user-friendly as currently users can only expand a subsection and close it by opening another sub-section. It would also be useful to have an optional field to include references for inputted data which is currently not provided.

In addition, it has been suggested to include a visual display of the model with all data inserted by the user in order to further improve transparency and user-experience. Further to that, several test users have reported that the "Patient flow through model states" section is unclear. This reflects the difficulty to provide a user-friendly tool for non-experienced users without having to go too deep into decision modelling and/or health economics concepts. To handle this and potentially other issues that inexperienced users might find confusing, an online help function and a user manual would be desirable.

Finally, the interface could also be improved for EC staff at IPTS with administrator rights. For instance, data currently provided by users of the tool is being stored in a central database hosted at IPTS. Access to that database is provided in a very basic way by export function when logging in as tool administrator. Developing a more elaborate access to the database, perhaps with the option to search and select only the relevant data, may be desirable once users start using the tool and aggregation of results becomes possible to monitor the EIP on AHA.

Once EIP on AHA stakeholders start using the tool, feedback should be collected to identify and prioritise potential improvements to be made to the user interface.

3.3 Other software, coding and technical issues

The IPTS IT department have extensively tested the software in the EC environment. However, because the tool was developed in a language and framework not supported by the EC, some issues may have to be resolved, if the system is to be further developed.

The model itself has been developed in R and it may be advisable to get a R specialist to check the code and optimise it if needed. This is particularly important as, during tool development, the IPTS IT department already identified and corrected a number of coding issues that would have otherwise severely limited the functionality of the tool and/or the validity of its results. For instance, in the first full version of the tool delivered to IPTS, a probabilistic run with 1000 iterations would have lasted more than 4 hours in total. After analysing the R-code in-house, IPTS IT suggested an improvement to the R code which reduced the run-time for the very same analysis beneath 10 minutes. Likewise, in the original version of the model, one-off intervention costs were automatically divided by the total number of individuals belonging to the selected age/gender-cohort within the chosen country. As a result the impact of one-off intervention costs would have been severely underestimated when calculating the incremental cost for interventions not rolled out to the entire population section of a country. The results would have been severely biased towards the intervention and

therefore provided EIP on AHA participants with wrong information. To resolve this issue, the model and user-interface were adjusted so that users have to specify all intervention costs on a per-patient level.

As mentioned before, despite our utmost efforts to test and improve the tool before launching it, some errors that could impact on the performance or results of the tool may remain. As the current version of the tool is a prototype, practice testing will show whether there are remaining issues which will have to be resolved after public rollout.

4. Data collection and future implementation of MAFEIP

Besides model set-up and technical issues related to the MAFEIP tool, it is important to mention issues related to data collection and future implementation of MAFEIP within the EIP on AHA.

As for data availability, this has been a challenge all along the MAFEIP project. Initially, data was missing to identify and prioritise possible indicators that could suit the needs of a monitoring framework, and even once a conceptual model was proposed by IPTS, obtaining data from commitments in the context of case studies for testing the MAFEIP tool remained challenging. As a result, in parallel to the development of the MAFEIP tool, IPTS invested significant resources in approaching and visiting selected commitments in order to discuss data needs and establish cooperation. Only because of these efforts, data could be obtained for carrying out a total of three case studies: one on an early technology to predict falls in older people; another one on a telehealth intervention for mobile monitoring and training of frail patients; and a third case was built by a test user based on data from a mobile monitoring and training application for diabetic patients.

This highlights the major challenge ahead for carrying out a meaningful monitoring of the EIP on AHA within the time horizon of the EIP initiative (2020). The EC will have to undertake more awareness raising activities to 'sell' the added-value of the tool for individual commitments and stakeholders to make sure that some data can be collected. In addition to spreading knowledge about the availability of the tool itself, effort should be focused on making the use of the tool as easy as possible and demonstrating its benefit. This should include not just the development of a user manual and additional online support for MAFEIP users, but also investment into further case studies to build up an evidence base for the Monitoring Framework. Closely related to this, workshops and seminars for EIP on AHA stakeholders should be developed to enable them to use the MAFEIP tool in the context of their activities within the EIP on AHA.

5. Conclusion

In order to monitor the impact of the various activities carried out by the stakeholders of the EIP on AHA towards its headline target and the triple win, a web-based monitoring tool has been developed by DG JRC IPTS.

This tool builds up from a variety of surrogate endpoints commonly used across the diverse set of EIP on AHA commitments in order to estimate health and economic outcomes of the Partnership. Stakeholders can access the tool through an intuitive web-based user interface that is linked to a database of country, age and gender specific mortality data. A three-state Markov model runs in the background of the tool which allows estimation of lifetime impact of an innovation on quality adjusted life expectancy as well as health and care expenditure.

The MAFEIP tool allows not just monitoring the impact of the EIP on AHA towards its overall objectives, which was the main aim of the MAFEIP project, but it enables stakeholders of the Partnership to perform an early and iterative assessment of innovations' cost-effectiveness at various stages of the development process. This could be useful for assessing the potential of a new technology in order to inform decisions upon further design, investment, and evaluation, and to provide appropriate support for innovations to facilitate faster progress to the next stage of development and/or implementation.

This report discussed issues encountered with the set-up of the model, the usability of the tool, technical issues and further gaps that were identified in the course of the tool implementation, as well as issues related to data collection and public rollout of MAFEIP. It further offers recommendations as to what improvements could be undertaken in the future.

Major tool developments to be considered aim at improving its flexibility and ability to be adapted to different contexts through, for instance: the optional inclusion of additional health states in the model; the ability to insert more nuanced data for model parameters; enabling explicit assessment of heterogeneity amongst patients; and also allowing for (selected) multivariate sensitivity analysis. However, whilst each of these potential tool improvements has the ability to increase its flexibility and enable better adaptation to various interventions, patients, and care contexts within the EIP on AHA, they all increase complexity, which in turn impacts the amount of data required and the experience needed to make the best use of the MAFEIP tool. In the light of this trade-off, decisions need to be made in order to prioritise potential improvements to be made to the MAFEIP-tool.

In terms of technical issues, it needs to be highlighted that the current version of the MAFEIP tool, which DG JRC IPTS developed together with external contractors, is a prototype. Despite our utmost efforts to test and improve the tool before launching it, including through internal and external validation, the conduct of several case studies and consultation with experts, DG JRC IPTS cannot exclude the possibility of remaining errors that could impact on the performance or results of the tool. Practice testing will show whether there are remaining issues which will have to be resolved after public rollout and users should be encouraged to get in touch with IPTS in case of any problems with using the tool, if they suspect a bug, or wish to suggest further improvements.

Finally, the EC should invest in activities to raise awareness of the added-value of the MAFEIP tool for EIP on AHA stakeholders (and potentially beyond) in order to foster its uptake, improve expertise within the EIP on AHA through seminars and workshops, and build up an evidence base for MAFEIP through the conduct of additional case studies.

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