**Developing a framework for public involvement in mathematical and economic modelling: Bringing new dynamism to vaccination policy recommendations**

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**Abstract**

**Aims** The Mathematical and Economic Modelling for Vaccination and Immunisation Evaluation (MEMVIE) programme aimed toexplore, capture and support the potential contribution of the public to mathematical and economic modelling, in order to identify the values that underpin public involvement (PI) in modelling and co-produce a framework that identifies the nature and type of PI in modelling and supports its implementation.

**Methods** We established a PI Reference Group, who worked collaboratively with the academic contributors to create a deliberative knowledge space, which valued different forms of knowledge, expertise and evidence. Together, we explored the key steps of mathematical and economic methods in 21 meetings during 2015-2020. These deliberations generated rich discussion, through which we identified potential points of public contribution and the values that underpin PI in modelling. We iteratively developed a framework to guide future practice of PI in modelling.

**Results** We presentthe MEMVIE Public Involvement Framework in two forms; a short form to summarise key elements a long form Framework to provide a detailed description of each potential type of public contribution at each stage of the modelling process. At a macro level the public can contribute to reviewing context, reviewing relevance, assessing data and justifying model choice, troubleshooting, interpreting and reviewing outcomes and decision making. The underpinning values that drive involvement include the public contributing to the validity of the model, potentially enhancing its relevance, utility and transparency through diverse inputs, enhancing the credibility, consistency and continuous development through scrutiny, in addition to contextualising the model within a wider societal view. We also present guidance for teams to implement the Framework during deliberative meetings.

**Discussion and Conclusion** Public involvement in modelling is in its infancy. The MEMVIE Framework is the first attempt to identify potential points of collaborative public contribution to modelling, but it requires further evaluation and refinement that we are undertaking in a subsequent study.

**Background**

Public involvement (PI) has become increasingly embedded within health research nationally and internationally. PI is defined by INVOLVE in the UK as research that is undertaken ‘with’ or ‘by’ patients or members of the public, rather than ‘to’, ‘about’ or ‘for’ them [1]. It refers to their role as part of the research team effort, not their role as research subjects. It can include people becoming members of the research team, being part of PI reference or governance groups, involved at key points in the research process. The intention of patient and public involvement is to prioritise and undertake research that creates optimum public benefit by ensuring research is relevant, acceptable and appropriate from the patient or public perspective. During their involvement, patients and public contributors share their unique knowledge, expertise and perspective. This active involvement is different from patients or public participating as passive research subjects in clinical trials or research studies with little contribution to identifying need, design, conduct or interpretation. It also differs from forms of public engagement which aim to create a dialogue between researchers and the public to improve public awareness and understanding about research [2]. In this study, we use public involvement to refer to inputs from the public rather than patients, acknowledging these can be different [3]. Recently, the focus has been on the concept of ‘co-production’ of research between researchers and the public with the key principles of sharing power, including all perspectives and skills, respecting and valuing the knowledge of all those working together, reciprocity, and building and maintaining relationships [4].We drew on the concept of co-production, which we acknowledge is a rare approach in modelling. The notion of co-production is founded on a number of elements or principles. These have been variously defined in the literature, but it is possible to discern five core elements in services [5] that are relevant in research. In identifying these Heaton et al [5] use the term ‘users’ to refer to the service context. For consistency we use public contributors. First, in the process of co-production, public contributors are regarded as active agents and not merely passive subjects or recipients of services (or research). Second, there is greater equality in the relations between public contributors and professionals, with services becoming more people driven, with their knowledge and experience being valued on a par with that of professionals. Third, public contributors and professionals recognise that they can achieve more by working together than they can apart; both also find their relationship to be reciprocal and mutually beneficial. Fourth, public contributors increased participation transforms the ways in which public services (or research) are designed and delivered, developing capacity for public contributors present and emerging needs to be met. Fifth, the participation of public contributors in the co-production of services (or research) is encouraged and facilitated by networks and organisations that support their involvement (although it is recognised that it is people, not systems, who create change).

Ideally, the practice of public involvement is based on an understanding of the values that underpin it as they often reveal key motivations. These values may vary among individuals within a team, making it important to explore them before and during a study. Gradinger et al [6]identifies a range of value systems and value clusters underpinning involvement that includes normative values focused on moral, ethical and or political concerns associated with PI in research (empowerment, rights, ethics); substantive values that focus on concerns about the consequences of PI in research (quality/relevance, validity, reliability) and process values that focus on concerns about the conduct of PI in research (respect/trust, openness and honesty).

PI has become embedded in many areas of health research, where values and different approaches have been explored. However, there are areas where PI is much less common. These include complex areas such as mathematical and economic modelling, which draws together both epidemiological and economic data to predict the incremental health benefits of implementing different intervention strategies on populations. A broad definition of amathematical model is a“mathematical framework representing variables and their interrelationships to describe observed phenomena or predict future events.” The epidemiological component of the model captures all the health related outcomes associated with implementing an intervention [7]. The health economic components of the model captures the costs and ultimately the cost-effectiveness of the intervention [8]. The aim is to provide decision makers with the best available evidence to reach a decision—for example, indicate whether the incremental health benefits are worth the incremental cost associated with an intervention [9]. Past examples offer insights of the potential for public involvement to contribute to vaccination policy. In 2013, after analysis of the available cost effectiveness models, the Joint Committee for Vaccination and Immunisation (JCVI), an independent expert advisory body for vaccinations in the UK, advised that that a novel vaccine to prevent meningococcal group b disease would not be cost effective at any price [10].  However, following evidence submissions from stakeholders including patient groups, the models were rerun to include disease specific costs and health benefits which had previously been omitted from the analysis [11], which led to the eventual national introduction of the vaccine for UK babies in 2015.  Although the vaccine was introduced for babies, a health petition called for wider access for older children [12].  Scrutiny of the cost effectiveness analysis of the MenB vaccine raised a wider question about whether current cost effectiveness methods adequately reflect the health characteristics the public value the most when prioritising health spend. Whether the cost effectiveness methodology for vaccines is adequate is an area which is still debated and Government has not formally adopted the recommendations from a working group set up to address this question [13].  However, involving patients and the public in all stages of health economic analysis has the potential to introduce some of these issues to policy makers and modellers early on and could enhance models, improve confidence in and ultimately accelerate decision making.  PI in modelling could also play a pivotal role in highlighting key areas for further research in order to more accurately reflect public preference in cost-effectiveness modelling in the future.

The Mathematical and Economic Modelling for Vaccination and Immunisation Evaluation (MEMVIE) study focused on vaccination, an effective tool in the fight against a range of infectious diseases, but generally associated with considerable costs. The UK spends in excess of £200 million per year on vaccines and vaccine delivery [14]. In this context, epidemiological and economic models are important in forming judgements about the

cost-effectiveness of the introduction of, or a change to immunisation programme. The MEMVIE study, commissioned by the UK Department of Health in 2015, provides second opinion modelling, enabling the Department of Health in England to compare the models developed by the University of Warwick with those developed by Public Health England as a form of validity check, a common approach in modelling. Model outputs are subsequently presented to JCVI, the key programme decision maker. While modelling can be a very effective tool, views differ about the extent to which models truly capture the entirety of a concept or a context, as they are often limited by both the availability and quality of data, and assumptions used. As George Box said, *“essentially, all models are wrong, but some are useful"* [15], reflecting a realistic view of the limits of modelling. Although Box did not mention public involvement, our extrapolation of Box’s view is that models can benefit from additional sources of input, such as PI, to help strengthen the thinking that sits behind them. As the intention of a model is ideally to capture all the relevant variables that represent a phenomenon, this offers an opportunity to co-produce such a model with the public. Different forms of experiential and community knowledge can complete the ‘world view’ that may be required to create a `less wrong model.’ In addition to contributing to the model, patients and the public represent potential end beneficiaries, as well as being the ultimate funders of vaccination services through taxes (in the UK). As such, it can be argued there is a moral imperative to involve the public as key valued and impacted stakeholders, often captured by the phase used in PI circles “Nothing About Me Without Me.” In commissioning MEMVIE, the Department of Health in England recognised the role the public could have in creating models that are more relevant, appropriate and acceptable from a public perspective. The investigation of the role of PI to inform such modelling were novel at the time of the commissioning of the contract by the Department of Health in 2015.

In scoping the literature, it became apparent that mathematical and economic modelling has not embraced the potential of active public involvement either philosophically, in terms of perceiving any value, or methodologically in practice. We were not able to identify any modelling studies that had reported their active collaborative public involvement, or that had provided a framework to guide PI practice in mathematical and economic modelling. It became apparent that in order to embed public involvement within the MEMVIE study, we needed to first undertake an exploration, to identify where and how the public could contribute to modelling, understand the values that drive that involvement and develop a framework that could support other academic groups in their implementation of public involvement in modelling.

**Aims:**

1. To explore and capture the potential areas of contribution of the public to mathematical and economic modelling.
2. To identify the values that underpin public involvement in modelling.
3. To co-produce a PI framework that identifies the nature and type of public involvement in modelling and supports its implementation.

**Methods:**

Public involvement can be described as a form of social practice and can be informed by evidence that guides best practice. We drew on the learning from the RAPPORT study that emphasises the importance of high-quality relationships, developed in arenas that support contribution, enables a sense of reciprocity and provides enough time for exploration and discussion[16]. As this study focused on working with public contributors s as partners in research, rather than subjects of research, ethical approval was not required [17]. However, we drew on principles of good ethical practice in PI [18] and GRIPP2 to report the PI in MEMVIE, see appendix 1 [19]. We are all one research team, each contributor with different skills and experiences.  There are two groups, in one group the skills are centred on academic profile, in the other group, their skills arise from practical living experiences and a wider societal view. The two groups, together focussed their attention on the research question. We have called these groups public and academic contributors.

**Key stages of framework development**

We identified the following key stages needed to develop the MEMVIE framework. These were iterative rather than linear, depending on what emerged from discussions. **Recruitment of public contributors**: We used an informal interview process, intended to identify individuals who had relevant health knowledge, experience and learning, potentially gained through different channels (including previous PI projects and their community roles). We drew on the Warwick Medical School Public Involvement UNTRAP Network which includes patient contributors from diverse backgrounds who are not academics. The informal interview explored how potential public contributors felt about working in a complex area such as modelling. Public contributors needed to be comfortable and confident when asking questions about methods. There would be many sessions focused on learning about the methods and potentially several moments of uncertainty when people realised it may take a while to understand a method. They also needed to be comfortable with having no prescribed route map, as we embarked on our exploratory journey together.

**Establishing a deliberative knowledge space:** The development of the Public Reference Group meetings (which included the public contributors and academic contributors) reflected the concept of a deliberative knowledge space [20,21].Creating a deliberative knowledge spaceallowed participants to consider and discuss relevant information from multiple points of view, drawing on their own different expertise, knowledge and values as the lens through which to view a disease or a method [21]. The first few meetings were exploratory as we discussed how we would examine PI in modelling. As we progressed, the meetings started to follow a more logical path through learning (about the diseases and modelling methods) and discussion. As public contributors built up their knowledge, they gradually developed their capacity to identify potential PI contributions [20]. Discussions were facilitated (by PI Lead SS) to ensure that a diversity of views from people with different perspectives were included and that everyone’s contribution was valued and listened to. We ensured meeting places were relaxing and conducive to discussion, moving venue during the project to ensure a higher quality environment.

**Understanding modelling methods:** An essential activity, which happened in almost every PI Reference Group meeting, was the explanation given by researchers about the methods. Presentation of methods ensured that public contributors felt comfortable asking questions and discussing modelling aspects, enabling them to reflect upon and explore the methods presented. Specific sessions on particular topics were often repeated as learning could be lost in between meetings as meetings took place between 4-5 times per year over the 5 year period.

**Emergence of the framework**

Creating a deliberative knowledge space enabled possible areas of public contribution to modelling to emerge, as public contributors were seen as active agents, with their knowledge equally valued and with power shared in how decisions were made in what to include in the framework. Both sides found their relationship to be reciprocal and mutually beneficial. We recognised that the early discussions of PI in mathematical and economic modelling represented a “liminal” space, an in-between place or a place of transition, where there were no conventions of what public involvement in modelling might look like but one where we valued the potentially transformative contribution a co-production approach could bring [21]. This liminality initially felt uncertain and very uncomfortable for both public members and the research team, and facilitation by the (SS) was important in reassuring everyone that this feeling was normal. As meetings progressed a dialogue emerged, within which it was possible to identify potential areas of public contribution to modelling.

We captured ideas by recording meetings rather than taking detailed notes. This provided the group with a more detailed record of their discussion if we wished to use these. However, these recordings *did not* provide research data in the conventional sense from which thematic analysis could be derived. Rather, from these discussions and reflections, we started to build up a list of areas of possible contribution, which gradually built up into categories that eventually formed the framework. PI lead SS captured the categories identified in the discussion, which we reviewed at each meeting, with the public contributors refining and discussing new categories with the academic contributors each time. This process took five years, partly because of the co-production element, but was necessary to create the appropriate knowledge space for exploration in such a complex liminal space [20,21]. As the categories in the framework became clearer, the public contributors suggested we group the categories, mapped to the key steps of modelling, to facilitate the use of the framework by the modelling community (fig 1).

**Identification of values**

Values are important in public involvement as they can motivate individuals in different ways [6]. As we conceptualised public involvement in modelling as taking place within a liminal space, one that had not yet been explored and where things were unclear [21], we enabled the values to emerge during the discussions to ensure they were the result of a co-production process Once we had identified the values we then compared them to those identified by Gradinger and colleagues as a form of reflection rather than validation [6].

**Results**

We structure our study outcomes as follows. First, we present the characteristics of the Public Reference Group contributors and the academic contributors with some quotes about process. Second, we report the values that our meetings identified as underpinning public involvement in modelling. Third, we consider key aspects of practical Framework implementation. Fourth, we present the short form version of the Framework, which summarises the main components to enable an overview (fig 1). The final section presents the long form Framework, which represents a very detailed description of potential PI contribution that research teams can use to replicate PI in their own projects (reported in full in appendix 2). It is important to emphasise that at this stage the MEMVIE Framework has not undergone a full evaluation, although one is being conducted within our follow-up study, namely MEMVIEER (Mathematical and Economic Modelling for Vaccination and Immunisation Evaluation and Emergency Response). Therefore, at present it is unclear which framework elements are vital to public involvement in modelling and which are optional. Prior to full evaluation, we would encourage teams to select and evaluate the aspects they feel are of most relevance to their specific project. In addition, public involvement in modelling is not a linear process, with some phases undertaken in different order to that illustrated by fig 1. We fully expect the framework to evolve over time as teams implement it and report their framework refinements.

**Characteristics of the PI Reference Group contributors and the academic contributors**

The public contributors included eight individuals at the start of the project with a further public contributor joining in the third year. They were recruited through the Warwick University UNTRAP (Universities/User Teaching and Research Action Partnership) Network and all were contributors were members of that network. They represented a range of ages, ethnicities and cultural backgrounds, different careers / professions / employment, a range of ‘family’ experiences, different lifestyles, different health issues within family / friendships and of different ages and form different generations. All of these provide a backcloth to the acceptance of a strategy their ‘roll out’ of vaccines and vaccination. Five people remained at its conclusion, with a range of expertise that included a biology background, health visiting, nursing, community development, and experience of patient organisation input into the cost-effectiveness modelling of meningitis vaccines. There was also a diversity in ages and caring responsibilities. The academic contributors included two mathematical and economic modellers at any one time, an economist and a social scientist. All contributors were comfortable with complex topics, a deliberative approach and being within an often uncertain, liminal space [21]. The PI contribution was led by SS as PI lead. This is an essential role to recruit, train, support and facilitate and organise PI involvement, capturing outputs and reporting impact.

**Values**

PI Reference Group discussions identified a range of values associated with the process of modelling and the use of model outputs (table 1). There was recognition that the public bring different forms of knowledge, expertise and broader societal perspectives that can add to the validity of a model, potentially enhancing its relevance, utility and transparency through diverse inputs. The concept of co-production to guide PI in modelling was recognised as relevant and important. The Reference Group identified the potential for PI to contribute to credibility and consistency of the model through this scrutiny and continuous improvement through development. Additionally, the group attributed importance to contextualising the model within a wider societal view and understanding the connections to other services and contexts. The Reference Group identified tacit values that may underpin public involvement in modelling and are important to acknowledge, such as the belief that vaccination is a public good.

We compared these values to those identified by Gradinger and colleagues [6]. We identified significant alignment, particularly with substantive values focusing on the consequences of PI in research such as effectiveness and research quality and on process system values, those concerned with conduct of PI in research. Regarding normative values, it was recognised that the output of cost-effectiveness modelling ultimately decided whether the public would have access to sometimes life-saving interventions and that certain methods used could create ethical dilemmas. For example, placing greater emphasis on long term health effects by using a lower discount rate can make or break whether a vaccine is deemed a cost-effective spend of public funds. A recent example of this is extending availability of the HPV vaccine to boys in the UK, which was only deemed cost-effective when longer term health benefits were considered. While the group are not decision-makers, they wanted to ensure that a full picture of the costs and benefits of interventions are considered. These may not always be well represented under the current cost-effectiveness rules, particularly for marginalised groups.

[Insert table 1]

**Evaluation of process**

The use of the concept of a deliberative knowledge space and think aloud techniques provided an open, non-prescriptive dialogue that enabled ideas and thoughts to emerge. The public contributors were able to challenge the data, the basis for the collection of data and the interpretation of that data, thinking outside of the box in a safe space where modellers could rework their thinking.

One of our public contributors stated that the process *“was more akin to embarking on a long journey on a complex ship, with no captain, with an unknown destination with no operating manual and a very mixed and unfamiliar crew who were trying to figure out how this ship works, how each crew member fits in whilst trying to write the outline of an operating manual for future passengers on a similar journey.”*

The meetings enabled thematic development over time as the Reference Group contributors worked with the academic contributors on continuous iterations of the emerging Framework. We held 21 MEMVIE meetings over five years, each lasting between two to three hours, with email contact in-between with the group commenting on documents.

Two quotes illustrate the public contributors journey and a third view from a researcher are presented in table 2.

[Insert table 2]

**Implementing the MEMVIE framework**

As PI in modelling for developing policy vaccination recommendations is in its early stages, the modelling community may need support to implement the MEMVIE Framework. The Public Reference Group suggested adopting a ‘What, How, When, Where, with Whom’ approach that a modelling team could use to plan for PI in their study (see appendix 3). A brief summary is provided below.

We encourage teams to define public involvement before they consider how to undertake it. A suggestion of co-production as an approach to PI is made [4,5]. However, as co-production is difficult with some aspects of modelling, it may be that teams need to recognise the current limits to co-production and perhaps draw on the ACTIVE Framework for PPI in systematic reviews [22], which recognises a range of levels of public input in different scenarios.

We encourage teams to use the concept of a deliberative knowledge space in which to hold discussion, to “think aloud” and to draw on standards [20,21] (such as UK INVOLVE standards) [23] and the developing PI evidence base to guide practice. The need for teams (particularly researchers) to undergo training in PI was seen as vital to developing appropriate skills that support the process. Facilitation of PI is key and a PI lead role is considered essential. Similarly, the need for the public contributors to undergo training in the basic methods of health economic evaluation was also seen as crucial. Furthermore, the values that are relevant to a particular project need to be identified (table 1) as they will be embedded through discussion and can help understand differences in view and perspective.

We encourage teams to be flexible according to the needs of the project, but recognise that by definition the ‘complete modelling team’ should include both researchers and public contributors. Evaluating process and outcome is crucial. One method proposed by our Reference Group was an impact log to capture key contributions after each meeting or key interaction. The log then forms the basis of a narrative model, which can provide a qualitative ‘story of model development’ in a way that replicates the quantitative elements with narrative, capturing key decisions, key assumptions, values and other aspects of discussion that public contributors feel are important. This qualitative, narrative model could be reported alongside the quantitative model.

**The short form MEMVIE Framework**

Due to the complexity and length of the MEMVIE framework, the Reference Group identified the need for a short form, or summary, of the Framework (see fig 1).The framework breaks down the epidemiological and economic components of the modelling. Each phase is labelled Ep (epidemiological) or Ec (economic), corresponding to the associated section of the long form framework in appendix 2 and should be read across horizontally. It is important to emphasise that this figure reflects one representation of modelling in order to demonstrate the potential for public involvement. Modelling can be flexible and iterative as a method. Through Reference Group discussion, we identified a range of potential macro areas of contribution for public involvement in modelling. The five overarching types of PI contribution (right hand column, Fig 1) are Reviewing Context and Relevance, Assessing Data and Justifying Model Choice, Troubleshooting, Interpreting and Reviewing Outcomes and Decision Making. Each of the components of these overarching areas is described in detail in the long form Framework.

[Insert fig 1 short form framework with the following figure caption: The left-hand side of the framework represents the epidemiological components of modelling. The middle section represents the health economic components of the modelling. Each phase is labelled Ep (epidemiological) or Ec (economic), corresponding to the associated section of the long form framework (Appendix x). The framework should be read across horizontally; that is Ep1. then Ec1, then Ep2, then Ec2, and so on. The left-hand side legend denotes the identified five types of PI contribution identified by the Reference Group: Patterend backgrounds illustrate the regions of the model pathway where the associated PI contribution type predominately features."]

**The long form MEMVIE Framework**

Each of these model steps described in the short form framework have a more detailed set of potential PI contributions presented in the long form, explained in appendix 2. The public Reference Group felt it was important to differentiate between the academic modelling team activity, the nature of the PI contribution and the components that support PI input. As with the short form, the framework should be read horizontally across, that is Ep1, then Ec1, then Ep2, then Ec2. We provide here an overview of the five overarching type of PI contribution.

The initial stage is concerned with reviewing the context and relevance of the model and determining the state structure; that is, determining what should go into the model, with inputs from disease specific experts and through reference to relevant literature. A contribution that the MEMVIE Public Reference Group made at this stage, when considering the transmission of pneumococcal bacteria amongst the population, was identifying the potential for uncertainty because the study used to identify underpin mixing patterns in the population was conducted 10 years previously and mixing patterns may have changed due to broader societal change [24].

Within assessing data and justifying model choice activity (PI contribution), a farther-reaching benefit of PI is the Reference Group querying the robustness of a tool or questionnaires that have been used to collect data. For example, our Reference Group requested to see the NATSAL survey questionnaire [25] to judge the quality of data that MEMVIE was drawing on.

The troubleshooting activity provided an opportunity for the modellers to host a series of thinking aloud sessions whilst the models were under construction. Any preliminary findings from the models were presented to the group and the influence of some of the factors thought to be contributing to uncertainty discussed in more detail.

The interpreting outcomes stage allowed the modellers to present their models and associated outcomes in their entirety. Both the economic and epidemiological models were merged together and it was an opportunity for the group to review the models and consider the sensitivity of the results in relation to the parameters used and critique the model assumptions. Another step for the PI group to consider was the impact of “rules” such as the time horizon considered for the evaluation and the discount rate used and how these rules affect the cost-effectiveness of the intervention under consideration.

The final stage was decision making. Whilst this phase would most likely be enacted by an independent committee of experts, PI contribution at this stage could be in the form of a report detailing the findings of the group which could be considered alongside the model or presented by public representation on vaccination committees themselves.

**Discussion and conclusion**

The MEMVIE study has been a key source of policy advice to the Department of Health in England, creating mathematical and economic models in a number of clinical areas including human papillomavirus (HPV), pneumococcal and influenza. We used each of these projects as opportunities to build PI into modelling, a highly technical process often hidden from public or patient scrutiny, and yet with the potential to impact their health provision and health status in significant ways. We were not able to identify an existing framework for collaborative PI in modelling and, therefore, we believe MEMVIE is the first framework internationally for PI in vaccination modelling with the intention of informing policy. The development of the MEMVIE framework demonstrates the feasibility of involving the public in the deliberation and decisions which inform models, providing that the context for implementation is appropriate.

Through the MEMVIE study we were also able to identify the enablers that can support public involvement in modelling; for example, the creation of a deliberative knowledge space. Understanding each other’s values was vital to recognising the different perspectives public contributors can bring, which need to be explored at the start and during the process [6]. Planning for implementation of PI in a study was seen as important and emerged from recognising that PI in modelling is novel and requires careful facilitation from a PI lead to support the entire team of academic and public contributors working together.

The idea of a deliberative knowledge space enabled the technical and practical-experiential forms of knowledge to come together in a context where effective contributions could be made, informed by many deliberative sessions learning about methods. Through the deliberations, we identified the need to develop a narrative model that could complement the quantitative model. This provided the ‘story’ of model development, making accessible the often-inaccessible equations and graphs. We will refine the idea of a narrative model in our next study, MEMVIEER, using a reflection and impact log to build up our understanding of contribution, guided by the MEMVIE framework.

As the primary beneficiaries of healthcare modelling, the public have a moral right to be involved as key valued and impacted stakeholders. Public contribution has the potential to ‘ground’ models in the reality of lived experience and behaviour and add to its interpretation and understanding. As Williams and Popay [26] say of the public *“they are themselves bearers of considerable lay knowledge of their own life worlds and through their own ‘stocks of knowledge at hand’, were skilled interpreters and translators of the ‘external’ evidence provided by professional experts in dialogue with whom they could share in the decision making about what was to be done.”*

Through deliberative discussion, challenging assumptions and enhancing the richness of the dialogue, model validity is enhanced, with models created that sensibly account for the complexity of a disease and of societal response. Extending Box’s approach [15], in the context of public involvement in mathematical and economic modelling, PI could “help models be less wrong and more useful.”

The key limitation of the MEMVIE framework is that is has yet to be evaluated or used in practice. This is the intention in our next study, MEMVIEER, but other modelling teams may wish to use all or part of the framework to guide their work. We would encourage them to publish their outcomes to further strengthen the PI evidence base in modelling, building high quality practice that enhances the validity and utility of models, making models more accessible and accountable to the public, and creating significant patient and public health benefits in addition to furthering public trust in recommendations.

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