

Population Impact Analysis: a framework for assessing the population impact of a risk or intervention

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ABSTRACT

Background To describe an organizing framework, Population Impact Analysis, for applying the findings of systematic reviews of public health literature to estimating the impact on a local population, with the aim of implementing evidence-based decision-making.

Methods A framework using population impact measures to demonstrate how resource allocation decisions may be influenced by using evidence-based medicine and local data. An example of influenza vaccination in the over 65s in Trafford to reduce hospital admissions for chronic obstructive pulmonary disease (COPD) is used.

Results The number of COPD admissions due to non-vaccination of the over 65 in Trafford was 16.4 (95% confidence interval: 13.5; 19.5) and if vaccination rates were taken up to 90%, 11.5 (95% confidence interval: 9.3; 13.8) admissions could have been prevented. A total of 705 (95% confidence interval: 611; 861) people would have to be vaccinated against influenza to prevent one hospital admission.

Conclusions Population Impact Analysis can help the 'implementation' aspect of evidence for population health. It has been developed to support public health policy makers at both local and national/international levels in their role of commissioning services.

Keywords evidence-based, population impact, public health

Background

The growth of interest in evidence-based public health practice has spawned new approaches to defining evidence in public health settings.^{1–3} To inform decision-making processes, these approaches take account of (i) the importance of understanding the context in which interventions are set; (ii) difficulties in standardizing interventions across different localities; and (iii) other forms of evidence, such as the social and political context. There is a growing body of evidence to support public health decision-making. For example, the work of the Cochrane Collaboration Health Promotion and Public Health Field,⁴ and the UK NICE reviews on promoting good health, and preventing and treating ill health (<http://www.nice.org.uk/>). The raw

evidence alone, however, usually provides insufficient support for organizations needing to make choices over how their scarce resources can best be invested, and the likely population impact of an intervention in a specific

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context. Rather decision-makers need to know information about potential interventions which have direct policy relevance such as:

- How many lives will be saved, admissions prevented and risk factors reduced by implementing an intervention?
- How will this impact on the health of the local population?
- Will there be an impact on health inequalities?
- How does this compare with other interventions? And hence do we know whether this intervention will be a 'better buy' than another, competing claim for funding?

Our current challenge in promoting evidence-based practice is to build on the systematic collection and synthesis of evidence to develop tools that will assist decision-makers in choosing interventions to implement. In the field of evidence-based medicine, this issue has been identified and some measures have been taken to help with implementation. For example, 'Clinical Decision-Support' tools have been developed, for use at the point of care.⁵ In the individual/clinical and population health fields, however, the risk reductions which have been identified from systematic reviews are rarely if ever applied locally and presented as impacts on local populations.

We have previously described population impact measures (PIMs) for use in a number of different settings,^{6–8} and as a method of incorporating economic assessments.⁹ The underlying philosophy is to take a population perspective to measures of health gain.

In this paper, we outline a framework, where local data (such as on the population size, demographics and level of inequalities) can be combined with the results of estimates of effect size from systematic reviews and meta-analyses to estimate the health gain that a local health care organization can expect from the introduction of a new or alternative intervention, or increase in the availability of an existing intervention.

We call this framework 'Population Impact Analysis'. This could be applied to any appropriate population for which resource allocation decisions are required. For example, in the English setting it can be applied to Primary Care Trusts (PCTs) which have had responsibilities for the health of their populations, including commissioning of services. PCTs therefore have had an opportunity to translate the theoretical ideals of evidence-based population health into practice. An example is given here of the use of Population Impact Analysis by a PCT. However, from 2012, the primary care commissioning consortia, National Commissioning Board and Public Health Commissioners in local authorities will take over this role from PCTs. The example below can be applied to all commissioners of health and wellbeing services.

Methods

The framework

Population Impact Analysis uses a framework based on the 'Population Health Evidence Cycle',¹⁰ which shows how to progress from asking the right question (ask), through collecting the data and making appropriate estimates (collect and calculate), to understanding, synthesizing and appraising the information (understand) and using the information in policy-making (use). The value of this is that it will focus the user on a series of steps, which should inform the policy decision, in the context of the local policy framework and priorities.

The following three steps are given below.

Ask

Identify the need and formulate a well-specified question. For example: 'What are the costs and benefits of going from current to best practice in the treatment of heart failure in my population?' We can think of this as a population version of the 'well-built' clinical question.¹¹ The categories of the well-built clinical question are highly relevant to Public Health questions, although we have added a terminal T to the mnemonic PICO (Population, Intervention, Comparison, Outcome) to represent the Type of question being addressed (this is consistent with the T added by others to represent the type of study being reviewed in the context of a systematic review¹²).

Box 1

Asking the Public Health question—PICOT

Population. To which population or part of your population does the question apply?

Intervention or risk factor (exposure). For an intervention: is the intervention aimed at the individual or the population (e.g. the environment)? At what stage of the disease process are you aiming (e.g. primary or secondary prevention)? At what stage of development is the intervention? Is there a policy option available? What type of intervention is it (e.g. health care, health care organization, environmental modification, community-wide education etc.)?

For a risk factor: can the risk for the population—rather than for the individual—be measured? What sort of risk factor is it (e.g. physiological variable, individual behaviour, social attribute, environmental exposure etc.)?

Comparison. What comparison group are you planning (e.g. before/after study, control group)?

Outcome. Which outcome measure are you going to have (risk factor level, death, hospitalization, quality of life, cost-effectiveness etc.)? Over what time period is the outcome to be assessed, and how does this relate to the policy cycle length? Will estimates of cost be made?

Type of evidence required. Is this an estimate of burden of illness aiming to quantify risk or benefit? Is this to examine the impact of risks or benefits on health inequalities (such as an ‘equity audit’), or the impact of a health policy initiative? Is this an economic evaluation?

Collect and calculate

Estimate the benefit (and harm) to the population of the intervention(s) or policy(s). This involves ‘collecting’ all the data required to ‘calculate’ PIMs. Moving towards real-time data capture will increase the value of the decision support by making it more timely and thus more relevant to current policy.

Box 2

Ingredients of the PIM

Data required for the calculation of PIMs are:

- What is the size and nature of the population or sub-population to which the programme is applied?
- What is the outcome you want to examine, as defined in your question? This might be deaths, hospital admissions, quality of life, cost-effectiveness etc.
- What is the baseline risk of this outcome in your population? In the absence of local data, you may have to use information from the literature or from similar populations.
- For a risk factor: what is the prevalence of the risk factor of interest in your population? This should use local data if possible, or you may have to make an estimate based on the literature.
- For an intervention, what is the difference in the current rate of application of the intervention and the intended use, or if a new intervention, what level of use of the intervention is anticipated?
- What is the degree of risk from the presence of the factor of interest, or the benefit resulting from the intervention you are introducing, on the outcome you have chosen to measure? This will usually come from a literature search. This should be in terms of a relative risk (or relative risk reduction) of the outcome you have chosen, given the risk factor (or the intervention).

The PIMs which make use of these data are as follows:

Population impact number of eliminating a risk factor (PIN-ER-*t*): ‘the potential number of events prevented in your population over the next *t* years by eliminating a risk factor’.⁸

The number of events prevented in a population (NEPP): ‘the number of events prevented by the intervention in your population over a defined time period’.⁷ These are fully described in the Appendix.

Understand

Present the data in a clear, understandable and relevant way. Provide alternative forms of presentation, such as text, numbers and pictures, recognizing that some forms of presentation are more accessible to some people than to others. You may wish to rank alternative interventions: by numbers of outcome events prevented, numbers prevented per unit cost or cost per number prevented. The application of values to the health gain identified through the PIMs will be important. As this may reflect local situations and policy priorities, we have not included utilities or values in the PIMs (unlike measures of cost-effectiveness or Burden of Disease measures), and suggest that this be done as part of a local prioritization process.

Use

Feed into decision-making process and implement change. This may involve change management, and should take into account the principles of knowledge management in using the data—generate, store, distribute and apply.¹³ For completeness, the reality is that the ‘explicit’ knowledge we are generating is set in the context of the ‘tacit’ knowledge of health care workers.¹³ This will require an appreciation of the ‘implicit’ knowledge held by those responsible for the implementation, and how the new ‘explicit’ knowledge can be shown to add to it. We might ask: What are the current drivers of the service provision? Have you identified the interest served by not adopting change? Have you identified the costs of change and no change? Have you identified the ‘implicit’ knowledge of those responsible for the implementation, and how this might be changed by the presentation of the new ‘explicit’ knowledge obtained through the Population Impact Assessment?

Results

Ask

How many admissions due to chronic obstructive pulmonary disease (COPD), among residents in the area served by the Trafford Primary Care Trust aged over 65s are i) caused

Table 1 The PICOT approach for the two examples under 'Ask' of the population health evidence cycle¹⁰

	(i) Numbers of hospital admissions due to non-immunization	(ii) Numbers of hospital admissions prevented by increasing vaccination rates and consequent cost reduction
Population	All residents of Trafford aged 65 years and over	All residents of Trafford aged 65 years and over
Intervention	Influenza vaccination—coverage was 72%, so non-coverage is 28%	Influenza vaccination—coverage is 72%
Comparison	For this question, we are not using a comparison group	An aspirational value of 90% coverage
Outcome	Number of admissions due to COPD over 1 year	Number of admissions prevented due to COPD over 1 year, and the associated cost reduction
Type of evidence required	Burden of illness based on calculation of PIN-ER-t	Burden of illness prevented, and cost consequence, using NEPP

by not having been given influenza vaccine and ii) can be prevented by increasing the vaccination rate?

The Table 1 below demonstrates the PICOT approach for the two examples.

Collect and calculate

Collect

Population size (*n*): 45 000 residents of Trafford are aged 65 years or more.

Baseline risk of hospitalization for COPD in the Trafford PCT is 4.3/1000 in this age group.

Current Vaccination rate is 72% (non-vaccination rate 28%).

Vaccination rate goal 90%.

Relative risk reduction of influenza vaccination on hospitalization for COPD—as pneumonia and influenza admissions—is 33%¹⁴: assumption that relative risk of not being vaccinated is thus 1.33.

It was not possible to collect the vaccination status of the patients admitted to hospital from routine data sources.

Calculation of PIN-ER-t

Population attributable risk (PAR) is $0.28 \times 0.33/1 + (0.28 \times 0.33) = 0.0846$ (or 8.46%).

PIN-ER-t is $450\,00 \times 0.0043 \times 0.0846 = 16.4$ (95% confidence interval: 13.5; 19.5).

Calculation of NEPP

NEPP is $450\,00 \times 0.0043 \times (0.90 - 0.72) \times 0.33 = 11.5$ (95% confidence interval: 9.3; 13.8).

Number needed to treat (NNT) = $1/(0.0043 \times 0.33) = 705$ (95% confidence interval: 611; 861). (Note: see Appendix for full details of formulae.)

Effective protection rates are not included in the calculations as they will vary from year to year according to the current strain of the virus. We have not included costs of

the extra vaccinations, as nurses are already employed and vaccines bought to cover the total eligible number.

Understand

8.46% of the hospital admissions for chronic lung disease are due to failure of all the population to be vaccinated against influenza (derived from the previously used measure: PAR). In the Trafford population this equates to 16.4 extra hospital admissions in a year (PIM PIN-ER-t).

You have to vaccinate 705 people against influenza to prevent one hospital admission for chronic lung disease (previously used measure: NNT). Increasing the vaccination rate in the Trafford population aged 65 and more from the current 72–90% would prevent 11.5 hospital admissions for chronic lung disease in a year (PIM NEPP). The average length of stay is 11.1 days with cost of an uncomplicated bed day £300, so this would reduce costs by £38 295.

Use

These data were presented to policy makers in the Trafford PCT and a number of other audiences, and considerable interest was generated. Before implementing the findings, it was felt appropriate to put this in the context of comparison of other potential savings by implementing other guidelines. Therefore, it was decided to restart the Population Health Evidence Cycle with a new question and compare interventions. The new question is:

How many admissions due to COPD, can be prevented by giving all Trafford residents over 65s Influenzae vaccine versus how many admissions due to COPD can be prevented by giving all Trafford residents over 65s pneumococcal vaccine?

Thus, the cycle starts again.

Discussion

Main findings of this study

The method for Population Impact Assessment follows the Population Evidence Cycle and calculates PIMs. The cycle is a simple framework, and is not dissimilar to other organizing schemes such as the Community-Oriented Primary Care cycle,¹⁵ or the Plan Do Check Act cycle in the quality improvement literature, or the equity cycle.¹⁶ It makes the user define the question and emphasizes the need for implementation.

Our framework requires the calculation of PIMs, which we consider relevant to local policy-making,¹⁷ and which may be of value in decision-making.¹⁸ Alternative measures of disease burden and benefit, such as the Burden of Disease or Cost-Effectiveness Analysis, could be used instead—the key issue is to make the calculations using local data wherever possible, relating the results to the population of interest.

We believe that use of Population Impact Analysis will encourage the local collection of local data. For example, it was not possible to collect the vaccination status of admitted patients from routine data sources. The addition of this data could enhance the PIMs calculated. The interrogation of hospital records could have augmented the local data and is an omission during the data collection phase.

In addition to providing necessary information to guide policy and programme implementation, Population Impact Analysis tools and processes have the potential to inform current impact assessment processes such as Health Impact Assessment and Health Needs Assessment. Health Impact Assessment²⁰ is ‘a combination of procedures, methods and tools by which a policy, programme or project may be assessed for its potential, and often unanticipated, effects on the health of the population and the distribution of these impacts within the population’. Population Impact Analysis will be a useful tool to assist in the synthesis of information to estimate potential anticipated and unanticipated outcomes of proposed developments. It will also support the quantitative estimation of health risks and benefits in Health Needs Assessment (<http://www.nice.org.uk/download.aspx?o=502009>).

We think that there is a need for ‘preference sensitive’ decision-support tools at the population as well as clinical level. The technical requirements for building such tools include assembling the most relevant measures of local population impact available, which will usually involve improving access to relevant local and published data, as well as practical guides for their use. Decision-support tools could also describe the impact of potential interventions to reduce inequalities on the health of the whole population. An

example of such tools can be found at a web site that calculates confidence intervals for the PIN-ER-*t*, one of the PIMs we describe in this paper (<http://simph.man.ac.uk/pinert>).

Some measures have been taken to help with the implementation of collecting and synthesizing evidence in order to develop appropriate decision-making tools. For example, ‘Clinical Decision-Support’ tools have been developed, for use at the point of care.⁵ In the individual/clinical and population health fields, however, the risk reductions which have been identified from systematic reviews are rarely if ever applied locally and presented as impacts on local populations.

We have started to develop decision-support tools to help health organizations put Population Impact Assessment into practice. Analogous clinical decision-support tools are well-established—supporting both clinical decision-making and risk communication—over 400 evidence-based decision aids have been described.⁵ O’Connor and colleagues describe two types of clinical decision aids—(i) those where effective options exist and all that is required is help with implementing change management; and (ii) those where ‘preference sensitive’ options exist and decision-support is required to describe the options and their outcomes and assign values to them.⁵

What is already known on this topic

We have previously described PIMs for use in a number of different settings,^{6–8} and as a method of incorporating economic assessments.⁹ The underlying philosophy is to take a population perspective to measures of health gain.

What this study adds

A Population Impact Analysis framework provides a:

- standardized tool for a variety of applications in public health practice;
- new framework to translate the evidence of risks and benefits from systematic collections of evidence to a local population;
- decision-support tool to help with implementing evidence into policy and practice.

Limitations of this study

The calculations of impact will depend on the accuracy of the variables used in the calculations. The measures of relative risk and relative risk reduction are the most sensitive to error, and the estimate we have used has come from just one study of relative risk reduction.¹⁴

Confidence intervals have been included, based on a simulation which has allowed for variation in each of the parameters used in the formulae. The estimates have also

not been adjusted for the presence of co-morbidities in the elderly populations to which we are applying them, however, the use of current treatment patterns and compliance make this measure sensitive to many of the factors previously discussed as important predictors of 'community effectiveness'.¹⁹

Local availability of data on prevalence of the conditions and use of health services will vary from place to place and condition to condition. In some settings, much of the data will have to be derived from the literature. Where local data are available, they will add considerably to the relevance of the measures made.

Conclusion

Population Impact Analysis is a tool that can help the 'implementation' aspect of evidence for population health¹ as well as providing a platform to link costs to estimations of population impact. It has been developed to support public health policy makers at both local and national/international levels in their role of commissioning services. In the current UK context, this could help PCTs and local authorities with their delivery plans and area agreements to commission services on a firm basis of evidence.

Box 3

Components of Population Impact Assessment

Ask the question—make the options explicit using PICOT framework.

Collect data and Calculate outcomes—local data on population denominator/prevalence and current practice (or published data from similar populations)/estimated data on baseline risk (from Public Health Observatory etc.)/literature for evidence for risks (relative risk or relative risk reduction).

To produce PIMs or alternatives.

Understand—synthesize and present results.

Use—implement results in prioritizing services using principles of change management and knowledge management.

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Appendix

Data requirements for calculating PIMS

The table shows the components of the PIMs, compared with the more traditional measures of risk and risk reduction.

	Risk		Intervention risk reduction	
	PAR	PIN-ER-t	NNT	NEPP
Population size		✓		✓
Prevalence of:				
Risk factor	✓	✓		
Disease or condition of interest				✓
Baseline risk of outcome over t years:				
in whole population		✓		
in untreated population			✓	✓
Risk or risk reduction				
RR of outcome given presence of risk factor	✓	✓		
RRR of outcome given intervention			✓	✓
Proportion of population with disease or condition of interest 'eligible for intervention' (requires: best practice goal, current treatment level, compliance with intervention)				✓

PAR, population attributable risk; PIN-ER-t, population impact number of eliminating a risk factor; NNT, number needed to treat; NEPP, number of events prevented in your population.

The Data

n = population size

P_d = prevalence of the disease

P_e = proportion eligible for treatment In order to reflect the incremental effect of changing from current to 'best'

practice, and to adjust for levels of compliance, the proportion eligible for treatment, P_e , is $(P_b - P_t) \times P_c$, where P_t is the proportion currently treated, P_b is the proportion that would be treated if best practice was adopted and P_c is the proportion of the population who are compliant with the intervention.

P_{exp} = proportion exposed to the risk factor.

r_u = risk of the event of interest in the untreated group or baseline risk over appropriate time period (can be multiplied by life expectancy to produce life-years).

RRR = relative risk reduction associated with treatment.

RR = relative risk associated with risk factor.

The formulae

Population attributable risk (PAR):

$$PAR = \frac{P_{exp} * (RR - 1)}{1 + P_{exp} * (RR - 1)}$$

Population impact number of eliminating a risk factor (PIN-ER-t):

$$PIN - ER - t = n * r_u * PAR$$

Number needed to treat (NNT):

$$NNT = \frac{1}{r_u * RRR}$$

Number of events prevented in your population (NEPP):

$$NEPP = n * P_d * P_e * r_u * RRR$$

(in our example we replace $n * P_d$ with the number in the population since all people over 65 are our target population, P_e , the proportion eligible for the intervention, is calculated as the difference between the target vaccination level and the current vaccination level).