Communicating risks at the population level: application of population impact numbers

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Communicating population risk to policy makers and the public is important, but traditional epidemiological measures of risk are difficult to understand. PIN-ER-*t*, a measure of the population impact of risk factors, is simpler to understand and hence may be useful

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Communicating levels of health related risks to decision makers and the public is increasingly important. Clinical and public health professionals are becoming familiar with best practice in communicating risk to individual patients or members of the public.[1] However, communicating risk to those who determine health policy has been less well studied. Although we do not have direct evidence of inappropriate health policy decisions being made, a questionnaire survey found health service managers seem to be inappropriately influenced by presentations of risk and benefit in relative rather than absolute terms.[2]

For understanding disease causation and to describe the impact of risk factors for disease, the traditional epidemiological measures are absolute and relative risk. However, these do not give a clear indication of the impact of a risk factor at population level, since they do not take into account the prevalence of the risk factor in a population. Epidemiological measures that do take this into account, such as population attributable risk (PAR), are difficult to conceptualise and remember and may be incomprehensible to non-epidemiologists. (In addition, different terms are used for PAR,[3] including population attributable fraction (PAF)[4] and population attributable risk proportion (PARP),[5] which can be confusing for expert and non-expert audiences alike.[6])

For a healthcare organisation to allocate resources effectively and develop services according to its health priorities, there may be value in producing and communicating numbers that show the impact of risk factors for disease in the local population in ways that can be easily calculated and understood. We have therefore developed the population impact number of eliminating a risk factor (PIN-ER-*t*), which can be defined as "the potential number of disease events prevented in your population over the next *t* years by eliminating a risk factor."

The impact of an intervention can be measured at an individual level with measures such as the number needed to treat.[7] However, such measures lack a population focus. In particular, they do not take into account the prevalence of a condition, and hence the population impact of an intervention. Ideal population equivalents of number needed to treat would be based on evidence of the effectiveness of interventions at the population level. As this evidence is lacking in most situations,[8] the next best way to assess population impact is by considering the risk factors that interventions are designed to reduce. Here, we combine epidemiological evidence of the relations between risk factors and health outcomes with local evidence of the levels of the risk factors and health outcomes in a population. The statistic produced, PIN-ER-*t*, is based on Levin's attributable risk[9] or, more descriptively, population attributable risk.[6 10] However, PIN-ER-*t* has the advantage that its calculation can be communicated as a simple sequence of steps, each involving numbers of people affected.

Calculating PIN-ER-*t*

The population impact number of eliminating a risk factor (PIN-ER-*t*) equals the population size multiplied by the risk of an event in the next *t* years, multiplied by the population attributable risk (PAR). PAR, which is the proportion of the risk that would be removed if the risk factor was removed,[3] can be calculated without knowing baseline risk from estimates of relative risk (RR) published in epidemiological literature, and the estimated proportion (P_e) of the population exposed to the risk factor.[6 11 12]

PIN-ER-*t* is calculated as:

$$\text{PIN-ER-}t = n \times I_p \times \frac{P_e(RR-1)}{1+P_e(RR-1)}$$

$$\text{PAR} = \frac{P_e(RR-1)}{1+P_e(RR-1)}$$

where n = population size,
P_e = proportion of the population with the risk factor,
I_p = incidence of the outcome in the whole population over *t* years,
RR = relative risk of an outcome event if the risk factor is present.

In order to reflect the feasibility of intervention, P_e might be modified to be the proportion of the popula-

tion with the risk factor who can be reached, and $n \times P_e$ thought of as the target population.

Given a reliable estimate of local baseline risk (I_u), alternative forms of the equations can be used instead, which extends the PIN statistic that we have previously described[13]:

$$\text{PIN-ER-}t = n \times P_e \times I_u\,(RR - 1)$$

$$\text{PIN-ER-}t = n \times (I_p - I_u)$$

$$PAR = \frac{I_p - I_u}{I_p}$$

Examples of use of PIN-ER-*t*

We calculated PIN-ER-*t* for a notional population of 10 000 people, such as a general practice population in Britain, using the distribution of various demographic subgroups within the UK population.[14] We did so for two different scenarios: firstly, to show the impact of smoking and social mobility on death from any cause, and, secondly, the impact of blood cholesterol concentration on death from coronary heart disease.

The time period (*t*) over which the consequences of a risk factor are being considered is important in the process of allocating resources for relevant health services. Most current reviews of health service resource in Britain take place in three-yearly cycles; we therefore used PIN-ER-3 for the examples below.

Impact of smoking and social mobility on death from any cause

We took the annual risk of death from any cause in men having either manual or non-manual occupations from data supplied to us by the Office for National Statistics as described previously.[15] The 2010 projected population is based on a hypothetical 5% increase in the proportion of the population in non-manual occupations. We took the prevalence of cigarette smoking in manual and non-manual groups from the 2001 general household survey.[16] We estimate a relative risk of death from smoking to be the same in manual and non-manual groups and to be 2.19.[17]

Table 1 shows that the population impact of smoking on mortality is considerably greater among manual than non-manual groups, because of the higher prevalence of smoking and the higher overall death rate among manual workers. There is a demonstrable impact of a small projected rise in the proportion of non-manual workers.

The public health rationale for focusing efforts to stop people smoking on men in manual occupations becomes clear from the PIN-ER-*t*. Table 1 shows that even the small demographic shifts associated with upward social mobility would be expected to reduce the population impact of social class, as we have previously shown.[15]

Impact of blood cholesterol concentration on death from coronary heart disease

We took the risk of death from coronary heart disease from the *Compendium of Clinical and Health Indicators 2001*.[14] The proportions of the English population in various categories of blood cholesterol concentration were taken from the *Health Survey for England 1998*.[18] We took the relative risks of death from heart disease by blood cholesterol category from McPherson et al,[4] the most up to date synthesis of relevant primary research on the impact of risk factors for heart disease in the UK population.[19 20]

Table 2 shows that different levels of blood cholesterol have different population impacts, depending on the size of the relative risk and the prevalence of the risk factor in the population. The population impact of blood cholesterol concentrations of 5.2-6.5 mmol/l and of >6.5-7.8 mmol/l is larger than that of concentrations above 7.8 mmol/l. This is because of the much greater prevalence of moderately raised cholesterol levels, despite the smaller relative risk increase, compared with the highest cholesterol group.

The ranking of the impact of different blood cholesterol levels on mortality from heart disease by PIN-ER-*t* is equivalent to that achieved with other derivatives of population attributable risk.[4] However, PIN-ER-*t* also shows the actual size of the benefit, which would make it easier for policy makers to determine priorities. The greater population impact of moderately raised blood cholesterol concentrations (table 2) clearly shows the importance of a population approach to prevention.[21] PIN-ER-*t* could also be used to compare the potential importance of population approaches with interventions aimed at high risk individuals. Estimating the relative costs of each approach would be an important feature in decision making

Table 1 Impact of cigarette smoking on death from any cause over three years in men aged over 25 years from a typical UK general practice population, split by socioeconomic group

Socioeconomic group	Relevant population size out of 10 000 (n)	Predicted three year incidence of outcome locally (Ip_3)	Estimated local prevalence of risk factor (Pe)	Relative risk from best evidence (RR)	Population proportion of outcome attributable to risk factor (PAR)	Estimated number affected locally in next three years (nd)	Population impact number by eliminating risk factor (PIN-ER-3)
In 1991:							
Non-manual workers (proportion 0.458)	1529	0.016059	0.22	2.19	0.21	24.56	5.10
Manual workers (proportion 0.542)	1810	0.025224	0.33	2.19	0.28	45.65	12.87
In 2010:							
Non-manual workers (projected proportion 0.508)	1696	0.016059	0.22	2.19	0.21	27.24	5.65
Manual workers (projected proportion 0.492)	1643	0.025224	0.33	2.19	0.28	41.44	11.68

PIN-ER-t=$n \times I_p \times$PAR
PAR=$[P_e \times (RR-1)]/[1+P_e \times (RR-1)]$
Risk factor=cigarette smoking
Outcome=death from any cause

Table 2 The impact of blood cholesterol concentration on premature death from coronary heart disease among people aged <75 years over three years in a typical UK general practice population, split by sex

Blood cholesterol concentration	Relevant population size out of 10 000 (n)	Predicted three year incidence of outcome locally (Ip_3)	Estimated local prevalence of risk factor (Pe)	Relative risk from best evidence (RR)	Population proportion of outcome attributable to risk factor (PAR)	Estimated total number affected locally in the next three years (nd)	Population impact number by eliminating risk factor (PIN-ER-3)
5.2-6.5 mmol/l:							
Men	4664	0.003624	0.41	1.75	0.24	16.90	3.98
Women	4591	0.001464	0.39	1.75	0.23	6.72	1.52
>6.5-7.8 mmol/l:							
Men	4664	0.003624	0.21	2.57	0.25	16.90	4.19
Women	4591	0.001464	0.22	2.57	0.26	6.72	1.73
>7.8 mmol/l:							
Men	4664	0.003624	0.07	3.46	0.15	16.90	2.48
Women	4591	0.001464	0.1	3.46	0.20	6.72	1.33

PIN-ER-t=n×I_p×PAR
PAR=[P_e×(RR−1)]/[1+P_e×(RR−1)]
Risk factor=high blood cholesterol
Outcome=death from coronary heart disease

based on PIN-ER-*t*, as shown for drug costs and total costs in prevention programmes.[22]

Potential limitations of method

Limitations of PIN-ER-*t*

We derived the PIN-ER-*t* statistic from PAR, and so it shares some of the limitations of PAR. Firstly, it estimates attributable outcome and not necessarily preventable outcome numbers, as it may not be possible to remove the risk factor from the population altogether. Hence the numbers may overestimate achievable impact and are therefore measures of potential impact. Replacing P_e with an estimated proportion of the population with the risk factor and amenable to change might be a solution to this; others have applied conservatism weightings.[23 24] In order to assess the impact of reducing a risk factor to some specified level, PIN-ER-*t* could be adapted by modifying the PAR component by statistical modelling.[25 26] Setting a specific level for the reduction of the risk factor, however, ideally requires evidence of the effectiveness of the proposed intervention, which is usually not available. On the other hand, the population impact of an individual risk factor may be underestimated due to interactions between risk factors, or impacts on other disease outcomes.

Limitations of data

The estimates of risk at the local population level will depend on the demographic characteristics, largely age structure, of the local population, the prevalence of the risk factor, and the relative risk of the health outcome with which it is associated. Our worked examples were for a hypothetical population of 10 000 based on national figures. For a real population, PIN-ER-*t* could be calculated from the best evidence of relative risks and reliable estimation of local prevalence of risk factors and incidence of outcomes.

PIN-ER-*t* and PAR vary with differences in relative risk. In our second worked example, of serum cholesterol and heart disease, we relied on a summary of primary evidence[4]: there is a case for more systematic synthesis of aetiological evidence than is available at present, perhaps with a global register of relative risks.

The local relevance and precision of PIN-ER-*t* can be improved by using local surveys of risk factors, and in the future by using health status and outcome measures from electronic health records and population based disease registers to assess local baseline risk. PIN-ER-*t* based on large numbers of events and measurements will be more precise than PIN-ER-*t* based on fewer data. Ideally, PIN-ER-*t* should be presented with a confidence interval, which could be constructed by computer based simulation, which examines the spread of PIN-ER-*t* after calculating it many times while varying outcome incidence, risk factor prevalence, and relative risk at random (we provide a web based simulator for PIN-ER-*t* at http://simph.man.ac.uk/pinert). In addition to considering natural variation when estimating the true PIN-ER-*t* in a population, we advise sensitivity analysis, such as varying P_e, to reflect different levels of amenability of the risk factor to change.

The issues raised in this article highlight the need to collect local data on health outcomes and on the distribution of demographic and risk factors in order to accurately assess their impact on local disease patterns so that locally relevant priorities can be set,[27] although the potential to derive better estimates of baseline risk from population based disease registers and linkage of electronic health records has not yet been realised.

Conclusion

We believe that PIN-ER-*t* is an easy to understand measure of the impact of risk factors at the population level, although it does require a degree of numeracy by the user. The potential value of the measure to a practice or primary care organisation is to allow it to estimate the relative importance of different risk factors and their impacts within different population subgroups. PIN-ER-*t* could be applied to a local population (possibly together with estimates of the impact of interventions at the population level using "number of events prevented in your population" (NEPP)[28]) and used in resource allocation decisions by comparing the impact of different aetiological factors and intervention programmes.

Summary points

Methods of communicating health risks to health policy makers have been neglected

Decision makers require easily understandable measures that show the impact of risk factors for disease on populations to help guide the allocation of resources according to local health needs

The population impact number of eliminating a risk factor (PIN-ER-*t*) is "the potential number of disease events prevented in your population over the next *t* years by eliminating a risk factor"

The PIN-ER-*t* can be used to show the impact of a range of risk factors in different populations and to compare the potential benefits of individual and population approaches to prevention

We have reported that individual clinicians are not as influenced by the presentation of risk in population terms as they are by relative risk (Heller et al, submitted for publication), while others have found that the "number needed to treat" statistic (which also relies on measures of absolute risk) is poorly understood by doctors and lay people.[29 30] It remains for us to examine whether new measures of population impact like PIN-ER-*t* can be more easily understood and used in health policy related decision making than traditional methods of communicating risk. We are developing a research programme to explore this further.

Contributors and sources: The authors work at the Evidence for Population Health Unit, aiming to develop a public health counterpart to evidence based medicine. The measure described here is one of a series of population impact measures developed to use evidence combined with routinely collected data to provide local context to measures of risk and benefit and support public health policy decision making.

Competing interests: None declared.

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Corrections and clarifications

Parathyroid hormone alone is as effective as combination in treating osteoporosis

We enthusiastically added a reference to this news article by Scott Gottlieb to help readers locate the study being reported (27 September, p 700). Unfortunately, although we got the year and volume of the *New England Journal of Medicine* right, we published the wrong page numbers. The correct reference is 2003;349:1207-15.

ABC of subfertility: male subfertility

Two errors crept into in this article by Anthony Hirsh (20 September, pp 669-72). Firstly, we incorrectly inserted an extra word in the caption to the figure on page 670; the caption should read: "Autosomal Robertsonian translocations may be associated with poor sperm quality and subfertility." Secondly, we made a dog's dinner of the caption to the figure on page 671. The photograph in fact shows a "microsurgical vasovasostomy for vasectomy reversal."

General practitioners and occupational health professionals

We inadvertently typed the word "health" instead of "medicine" when we inserted the competing interests for one of the authors of this editorial by Jeremy Beach and David Watt (9 August, pp 302-3). Professor Beach is in fact an assistant editor of the journal *Occupational Medicine*.