EVIDENCE BASED PUBLIC HEALTH POLICY AND PRACTICE

Population impact of stricter adherence to recommendations for pharmacological and lifestyle interventions over one year in patients with coronary heart disease

I Gemmell, R F Heller, P McElduff, K Payne, G Butler, R Edwards, M Roland, P Durrington

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Study objective: To assess the potential number of lives saved associated with the full implementation of aspects of the National Service Framework (NSF) for coronary heart disease (CHD) in England using recently developed population impact measures.

Design: Modelling study.

Setting: Primary care.

Data sources: Published data on prevalence of acute myocardial infarction and heart failure, baseline risk of mortality, the relative risk reduction associated with different interventions and the proportion treated, eligible for treatment and adhering to each intervention.

Main results: Adopting the NSF recommendations for pharmacological interventions would prevent an extra 1027 (95% CI 418 to 1994) deaths in post-acute myocardial infarction (AMI) patients and an extra 37 899 (95% CI 25 690 to 52 503) deaths in heart failure patients in the first year after diagnosis. Lifestyle based interventions would prevent an extra 848 (95% CI 71 to 1 614) deaths in post-AMI patients and an extra 7249 (95% CI 995 to 16 696) deaths in heart failure patients.

Conclusions: Moving from current to “best” practice as recommended in the NSF will have a much greater impact on one year mortality rates among heart failure patients compared with post-AMI patients. Meeting pharmacological based recommendations for heart failure patients will prevent more deaths than meeting lifestyle based recommendations. Population impact numbers can help communicate the impact on a population of the implementation of guidelines and, when created using local data, could help policy makers assess the local impact of implementing a range of health care targets.

See end of article for authors' affiliations

Correspondence to:
Dr I Gemmell, Evidence for Public Health Unit, School of Epidemiology and Health Sciences, University of Manchester, Oxford Road, Manchester M13 9PT, UK; islay.gemmell@man.ac.uk

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Population impact measures provide a population focus to the interpretation of the results of observational studies and randomised controlled trials^{1,2} and hence provide a population perspective to evidence based practice.³ These measures can be used to estimate the impact on the population of implementing health care recommendations. In March 2000 the UK government introduced the National Service Framework (NSF) for coronary heart disease (CHD).⁴ This NSF recommends, among other things, provision of appropriate treatment to post-acute myocardial infarction (AMI) patients (standards seven and twelve) and to patients with heart failure (standard eleven). Specifically the NSF recommends that 80%–90% of post-AMI patients are prescribed aspirin, β blockers, statins, and ACE inhibitors where appropriate and that 80%–90% of heart failure patients are prescribed diuretics, β blockers, and ACE inhibitors. The NSF also recommends that post-AMI and heart failure patients should be given advice on smoking cessation, physical activity, weight loss, and diet. In this paper we use population impact measures to estimate the potential impact of the implementation of these aspects of the NSF for CHD in England.

METHODS

We obtained estimates of prevalence of AMI and heart failure from statistics provided in the British Heart Foundation web site.⁵ The relative risk reductions associated with both pharmacological and lifestyle interventions were obtained from recent meta-analyses or systematic reviews where available. An estimate of baseline risk of mortality was derived from two studies that described the outcome of patients admitted to hospital with a diagnosis of heart failure

or a first admission for AMI in Scotland.^{6,7} We used the published mortality rates to estimate age and sex stratified risk of death after hospital discharge. We estimated the proportion of AMI and HF patients eligible for and currently receiving these interventions from UK based studies of primary care treatment patterns. Data on proportions of patients adhering to treatment were obtained from international studies in the absence of available published data relating to UK patients.

In this analysis we used two population impact measures; the “number of events prevented in your population” (NEPP) and the “number to be treated in your population” (NTP). Both of these measures have been described elsewhere³ for treatment with a single intervention and have been expressed algebraically as:

$$NEPP = n \times P_d \times r_u \times P_e \times RRR, \quad (1)$$

and

$$NTP = n \times P_d \times P_e \quad (2)$$

where n is population size, P_d is the prevalence of disease, r_u is the risk in the untreated, P_e is the proportion eligible for treatment, and RRR is the relative risk reduction associated with the treatment.

Abbreviations: AMI, acute myocardial infarction; NSF, National Service Framework; CHD, coronary heart disease; NEPP, number of events prevented in population; NTP, number to be treated in population; PSSRU, Personal Social Services Research Unit

The NEPP is used in this paper to estimate the extra number of events prevented in one year by the change from current practice to best practice if the NSF recommendations were implemented for drug treatment and lifestyle modification. The NTP is the number of people to be treated with each intervention package.

In our analyses we are assuming that patients receive a combination of treatments thus formula 1 has been modified. Mant and Hicks⁸ provide a comparatively simple formula for combining the proportion of patients treated with each drug and the different relative risk reductions associated with these drugs to get an overall treatment benefit associated with the drug combination. Mant and Hicks⁸ suggest that cumulative relative benefit of n treatments can be estimated as

$$1 - [(1 - P_{t1} \times RRR_1) \times (1 - P_{t2} \times RRR_2) \times \dots \times (1 - P_{tn} \times RRR_n)] \quad (3)$$

where RRR_1 is the relative risk reduction associated with treatment 1 and P_{t1} is the proportion of the population treated with treatment 1, RRR_2 is the relative risk reduction associated with treatment 2, and P_{t2} is the proportion of the population treated with treatment 2, etc.

To reflect the incremental effect of changing from current P_t , to "best" P_b , practice and adjusting for levels of treatment adherence P_a , the original version of NEPP, that simply estimated the number of events prevented if all eligible were treated, has been refined. To calculate the NEPP for an incremental increase in combination therapy we use P_{inc} to represent the incremental change in the proportion eligible for treatment so we have:

$$NEPP = n \times P_d \times r_u \times [1 - (1 - P_{inc1} \times RRR_1) \times (1 - P_{inc2} \times RRR_2) \times \dots \times (1 - P_{incn} \times RRR_n)] \quad (4)$$

where

$$\begin{aligned} P_{inc1} \times RRR_1 &= P_{b1} \times P_{a1} \\ &\times RRR_1 - P_{t1} \times P_{a1} \times RRR_1, \\ P_{inc2} \times RRR_2 &= P_{b2} \times P_{a2} \times RRR_2 - P_{t2} \\ &\times P_{a2} \times RRR_2, \\ P_{incn} \times RRR_n &= P_{bn} \times P_{an} \times RRR_n - P_{tn} \\ &\times P_{an} \times RRR_n \end{aligned}$$

for each of n treatments.

The risk in untreated patients, r_u is derived from the overall risk, the proportion treated with each intervention and the relative risk reduction associated with each intervention (see appendix available on line <http://www.jech.com/supplemental>).⁹ Our analysis assumed a one year time horizon, therefore we used one year period prevalence of AMI and prevalence of heart failure to estimate the number of events prevented in new cases if NSF targets were met. Formula 3 assumes that the separate RRRs are independent for each drug as are the proportion receiving each drug (that is, the patients chance of receiving a particular drug does not depend on their receipt of other drugs). It is reasonable to assume that the effects of the CHD drugs that we are modelling are independent and there is little evidence to invalidate the independence assumption between the classes of drugs described in this paper.¹⁰ Data from the Quality and Incentives in Practice¹¹ (QUIP) database provided by the National Primary Care Research and Development Centre (NPCRDC) suggest that the proportions of post-AMI patients treated with combinations of aspirin, β blockers, statins, and ACE-I are independent. The QUIP data also show that this assumption holds for lifestyle data but to a lesser degree. More patients get no interventions and more patients get two or more interventions than we would expect under the assumption of independence.

The incremental costs for implementing each intervention according to NSF recommendations compared with current practice were calculated using the best published estimates available. The total costs were calculated by multiplying resource use by the unit cost for each item. All costs were based on unit costs for the price year 2002 and the perspective was that of the NHS. The unit costs for each drug prescribed were obtained from the *British National Formulary*¹² and were applied to the most commonly used drug in each class based on data from the Prescriptions Cost Analysis (PCA) data for 2002. The cost of prescribing was obtained from Marshall¹³ and an additional cost of gastrointestinal bleeds in 2.5% of aspirin patients was included.¹⁴ The Personal Social Services Research Unit¹⁵ (PSSRU) estimates the cost of a GP consultation to be £20¹⁵ and if we assume four visits per year this gives a cost of £80 per patient. For the lifestyle based analysis PSSRU provides cost per contact for a health visitor as £29 in 2002, assuming three visits per year¹⁶ then the annual cost of providing lifestyle based advice is £87 per patient.

We used a simulation technique¹⁷ to provide confidence intervals for our estimates of NEPP and NTP. This technique entails simulation from theoretical distributions based on the data used to calculate NEPP and NTP. A simulation based distribution of each statistic is produced and the 95% confidence interval is obtained from the 2.5th and 97.5th centiles of the simulated distribution.

Table 1 Prevalence and risk of death after one year in heart failure and post-AMI patients

			Age group			
			Sex	55–64	65–74	75+
Post-AMI patients	One year period prevalence (%) ¹⁸	M	0.8	1.8	1.2	
		F	0.7	1.0	0.8	
	Risk of death by one year ⁷ (%)	M	4.65	8.25	13.50	
		F	6.20	11.0	17.99	
Heart failure	Prevalence (%) ¹⁹	M	2.73	4.17	8.77	
		F	0.88	1.69	7.35	
	Risk of death by one year ²⁰ (%)	M	19.02	23.34	27.78	
		F	19.07	23.41	27.86	

Table 2 Relative risk reduction for death from any cause in post-AMI patients

	Relative risk reduction		Source
	RRR	95% CI	
Antiplatelet	0.12	(0.02,0.22)	Baigent ²¹
β blockers	0.23	(0.15,0.31)	Freemantle ²²
Statins	0.21	(0.10,0.30)	Ward ²³
ACE-I	0.17	(0.03,0.29)	Domanski ²⁴
Smoking cessation	0.36	(0.29,0.42)	Critchley ²⁵
Dietary intervention	0.20	(-0.20,0.50)	Bucher ²⁶
Increased exercise	0.27	(0.02,0.46)	Jolliffe ²⁷

RESULTS

The literature review provided estimates of the one year period prevalence of AMI and prevalence of heart failure in the general population as well as the risk of death one year after diagnosis split by age and sex. Table 1 shows these data.

Tables 2 and 3 show the relative risk reductions associated with each intervention for post-AMI patients and heart failure patients respectively.

Using data from the QUIP database we estimated that 84% of post-AMI patients are prescribed aspirin, 61% are prescribed β blockers, 49% are prescribed ACE inhibitors, and 72% are prescribed statins. Using data from several UK based studies we estimated that 94% of post-AMI patients are eligible for treatment with aspirin,^{33–36} 80% are eligible for treatment with β blockers,^{34–37} 80% are eligible for treatment with statins,² and 75% are eligible for treatment with ACE-I.² Data obtained mainly from studies conducted in North America, because of a lack of such information being reported in UK studies, showed that 84% of patients adhere to treatment with aspirin,^{38–41} 81% adhere to treatment with β blockers,^{39–41} 81% adhere to treatment with statins,^{39–43} and 82% adhere to treatment with ACE inhibitors.^{39–41}

For heart failure the General Practice Research Database⁴⁴ provided the percentage of heart failure patients who were treated with β blockers and ACE inhibitors by age and sex between 1994 and 1998. This varied from 7.5% of women aged over 75 years prescribed β blockers to 72% of men aged 55–64 years prescribed ACE inhibitors. We increased each of the age and sex specific percentages by an average of 10 percentage points to reflect current practice. For spironolactone, the percentages were not available split by age and sex and our the estimated treatment rate was 25%.⁹ Studies have suggested that 65% of heart failure patients are eligible for treatment with β blockers,⁴⁵ 80% are eligible for treatment with ACE inhibitors, and 84%⁴⁵ are eligible for treatment with spironolactone.⁹ It proved difficult to obtain information on drug specific levels of adherence for patients with heart failure. There was no such information available for patients in the UK and the data used are from Germany⁴⁶ and the USA⁴⁷ that estimate that 77% of patients adhere to spironolactone and β blockers and 71% adhere with treatment with ACE inhibitors.

Estimates of the percentage of the post-AMI/CHD population who were eligible for, received, and adhered to lifestyle based interventions were derived from population based studies in the UK. These studies suggest that 29% of this population smoke,^{48–55} 52% have poor diet,⁴⁹ 68% are overweight,^{49–51} 53 20% are obese,^{49–51} 54 55 and 38% do little or no exercise.⁴⁹ 51 Several studies also provided information on the percentage of those who were eligible for an intervention that received the intervention in normal general practice. Of those who were eligible for smoking cessation advice, 56%⁵⁰ 52 received such advice and similarly, of those who were eligible, 14%⁵² received dietary advice, and 26%⁵⁰ 52 received advice on increasing levels of exercise. In some cases it was also possible to establish from the study the proportion that complied with the advice. In the case of advice on giving up smoking around 32% of patients gave up for at least six months after GP/nurse advice.⁴⁸ 52 56 About 34% of those who received advice improved their diet¹⁶ and 34% had increased levels of exercise after two years.¹⁶ Information on lifestyle based interventions was even more limited for heart failure patients and therefore proportions used for CHD were applied to the heart failure analysis. There was no evidence that obesity⁵⁷ 58 conveyed an increased risk of death in heart failure patients so the lifestyle based analysis for this group focused on smoking cessation and increasing exercise alone.

Table 4 shows the number of deaths that would be prevented per year in England by adopting the NSF recommendations for change from current to best practice for pharmacological and lifestyle based secondary intervention for post-AMI and heart failure patients. (A worked example is provided in the appendix, which is available on line <http://www.jech.com/supplemental>)

The population impact of the two types of intervention split by age and sex are shown in figure 1 for post-AMI patients and figure 2 for heart failure patients.

DISCUSSION

The number of deaths prevented by the introduction of health care interventions depends on baseline risk, disease prevalence, treatment levels, and the relative risk reduction achieved by the intervention. In our example the number of deaths prevented over one year through implementation of

Table 3 Relative risk reduction for death from any cause in heart failure patients

	Relative risk reduction		Source
	RRR	95% CI	
β blockers	0.35	(0.26,0.43)	Shibata ²⁸
ACE-I	0.26	(0.17,0.34)	Flather ²⁹
Spironolactone	0.30	(0.18,0.40)	Pitt ³⁰
Smoking cessation	0.29	(0.20,0.37)	Suskin ³¹
Increasing exercise	0.56	(0.13,0.78)	Rees ³²

Table 4 Impact of change from current to best practice in pharmacological and lifestyle based interventions among post-AMI and heart failure patients in England

	Post-AMI patients		Heart failure patients	
	Drug	Lifestyle	Drug	Lifestyle
Number of deaths prevented	1027	848	37899	7249
Number of people treated	37286	76317	353443	149044
Total cost of treatment*	£6641600	£6639569	£53702193	£12966868
Cost per death prevented*	£6464	£7834	£1417	£1789

*Price year 2002.

the targets recommended in the NSF for CHD is greatest for heart failure patients aged over 75 years. Meeting pharmacological based recommendations among these patients will prevent significantly more deaths than meeting lifestyle based interventions. Furthermore, our analysis suggests that achieving the NSF targets for heart failure will have a much greater impact on one year mortality rates than achieving the NSF targets for post-AMI patients. This is probably because of the poor one year survival rate among heart failure patients and because heart failure patients are currently less likely to be near "best" practice levels.

The NEPP provides a useful measure of the population impact of an intervention and until now has only been used to compare single drug interventions. Using the NEPP to assess the population impact of a combination of treatments however requires the assumption of independence of relative risk reduction and the proportion eligible for treatment and this might not always be the case. However, it is the inclusion of these parameters in the statistic that make it relevant to policy makers. If only a small proportion of the population are eligible for an intervention then even if it is highly effective, more impact may be had by introducing a less effective intervention that reaches more of the population. Population impact numbers can help a policy maker make these judgements.

This analysis has used published data to estimate the potential impact of the NSF for CHD in England over one year. There are several limitations associated with using published data. For example, it was difficult to find information for each component of the NEPP divided into the same age and sex categories. It is probable that the proportion treated and adhering to treatment varies by age and sex. It is also possible that relative risk reductions identified in patient groups selected for clinical trials may not be reflected in the general population. In particular, the relative risk reduction for exercise based intervention for heart failure patients although derived from a meta-analysis was actually only based on one trial⁵⁹ that recorded mortality. Furthermore, many published sources use imprecise definitions of disease status and outcome. In our particular example the NSF itself is rather vague, making the process of identifying the most appropriate source of data even more difficult. The paucity of published data in this field has been described by other researchers. Unal,⁶⁰ in a study evaluating the effect of population level changes in risk factors and the development of treatments on levels of CHD in England and Wales, commented that "Limited primary care data on consultation rates, prescribing and treatment uptake were available from published audits and studies." Rutten⁶¹ also commented that "Data on diagnosis and management of

Figure 1 Number of deaths prevented in post-AMI patients if current practice was modified to meet the recommendations specified in the NSF. **Figure 2** Number of deaths prevented in heart failure patients if current practice was modified to meet the recommendations specified in the NSF.

Policy implications

- Changing from current to best practice for pharmacological treatments for heart failure patients would prevent more deaths in the first year after diagnosis than similar changes in treatment for post-AMI patients.
- Population impact measures can be used to provide a population focus to the impact of evidence based practice and could be used at the local (primary care trust) level to evaluate the local impact of implementing a range of health care targets.

heart failure in every-day care are scarce" while Capewell⁷ commenting on the lack of availability of information on risk of death after AMI stated that "Population based studies are uncommon, the recent outstanding example being MONICA. This, however concentrated on 28 day survival." In this analysis we have used a one year end point because this was the most consistent of the time periods for which we could obtain outcomes in the various studies reviewed. A longer time frame may change the relative importance of different interventions both within and between conditions as levels of treatment, adherence to treatment, and costs will vary over time.

The limitations in the underlying measures may undermine the public health message presented here, however this analysis shows the strength of this type of methodology in assessing the impact of a population based intervention such as the NSF for CHD. There is thus a cogent need both to improve the routine collection, quality, and accessibility of local and national morbidity, prescribing, and adherence data both for pharmacological, lifestyle, and other interventions if the full potential of evidence based medicine based on sources, such as randomised clinical trials, is to be realised and used to its utmost effect in planning healthcare on a population level.

The appendix giving a worked example of the method used in this article is available on line (<http://www.jech.com/supplemental>).

Authors' affiliations

I Gemmell, R F Heller, P McElduff, G Butler, R Edwards, Evidence for Public Health Unit, School of Epidemiology and Health Sciences, University of Manchester, Manchester, UK

K Payne, North West Genetics Knowledge Park, University of Manchester

M Roland, National Primary Care Research and Development Centre, University of Manchester

P Durrington, Division of Cardiovascular and Endocrine Science, Department of Medicine, Manchester Royal Infirmary

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