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Fewer Doctors? More Nurses?
**A Review of the Knowledge Base
of Doctor-Nurse Substitution**

Gerald Richardson
Alan Maynard

DISCUSSION PAPER 135

FEWER DOCTORS? MORE NURSES?
A REVIEW OF THE KNOWLEDGE BASE OF DOCTOR-NURSE
SUBSTITUTION.

by

Gerald Richardson

and

Alan Maynard

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THE AUTHORS

Gerald Richardson is a Research Fellow at the Centre for Health Economics (CHE) at the University of York. Alan Maynard is Professor of Economics and Director of CHE.

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ABSTRACT

The combination of different skills used to provide particular types of primary and hospital care varies considerably from general practice to general practice and from hospital to hospital. Furthermore, skill mixes are changing rapidly as decision makers attempt both to reduce labour costs and enhance the quality of patient care.

The remarkable thing about this experimentation with different types of skill mix is that there is little evaluation of its effectiveness and cost-effectiveness. What is the evidence base about the effectiveness and cost-effectiveness of substituting doctors with nurses? The review of the literature presented here suggests that between 30 and 70 per cent of the tasks performed by doctors could be carried out by nurses. It has also been suggested that 30 per cent of doctors could be replaced by nurses, and it is shown that hundreds of millions of pounds might be saved if skill mix could be altered in this way.

How valid is such a conclusion? The evidence base is very small, with most of the studies having significant defects in their design. Furthermore, most of the studies are North American and quite dated (having been undertaken in the 1970s and 1980s). Thus the generalisability of the results of these effectiveness and cost-effectiveness studies to the present day United Kingdom is very limited. Consequently an estimate of the potential savings arising from altering the skill mix must at present remain speculative.

In the United States, managed care firms are changing skill mix radically, in particular by developing primary care. The scope for such changes in the NHS may be more limited and can only be identified by appropriate research i.e. prospective trials which compare the costs and effects of alternative skill mix combinations. Without such evaluation there is a risk that the quality of patient care will be reduced in the search for financial economies.

1. INTRODUCTION

1.1. Skill mix.

Different combinations of staff (for example, doctors, nurses and auxiliaries) can provide patient care within a given setting. Altering this skill mix, for instance by substituting nurses for doctors, has been proposed for the last 25 years, and has been implemented in several countries, including the UK. A number of questions on skill mix are addressed in this paper e.g. what percentage of doctors' tasks can be carried out by other health professionals without any detrimental effect on the quality or the outcomes of care delivered to patients? Are such changes cost-effective i.e. how can the current skill mix be altered to use less resources without adversely affecting patients?

Measuring skill mix is a complex task. Skill can be defined in terms of a number of variables e.g. experience, knowledge and qualifications, and measuring these factors across a number of combinations of providers is a complex and difficult process. Similarly, demonstrating that changing the skill mix by substituting nurses for doctors is cost-effective is complicated and a number of methodological problems may make measurement both difficult and sometimes imprecise.

1.2. Problems associated with skill mix/substitution studies

There are a number of recurring problems associated with the studies of skill mix. Methodological difficulties include:

- 1) It is often difficult to identify the proportion of a task carried out by the nurse because many of their tasks require supervision from a doctor.
- 2) It is often difficult to measure the effectiveness of nursing/medical care in terms of enhanced health. Often measures of process (e.g. patient satisfaction) are used to proxy outcome. To demonstrate conclusively that substitution is cost-effective requires either that nurses provide equivalent or superior health outcomes at a lower cost, or

that their utilisation results in better patient outcomes for the same level of costs.

- 3) Obtaining a representative group of patients and providers in evaluation studies can be problematic. This is a particular problem in many of the earlier studies which were based on providers who volunteered to be studied. Such samples are likely to be significantly different from the general nursing population and thus the results of evaluation cannot be generalised.
- 4) To demonstrate that doctor/nurse substitution is viable in the general case, a large number of providers would be required (with an even larger amount of patients) at a variety of sites. Multi-site studies are expensive and difficult to manage.

These methodological problems make the collection of adequate data to demonstrate the cost-effectiveness of particular doctor-nurse skill mixes a complex task.

1.3. Implications of skill mix for policy makers.

Policy makers in a health care system characterised by cash limits and cost-containment are aware of the need to employ the labour resources available to them in the most cost-effective manner. This includes not only the substitution of doctors by nurses, but also the substitution of lower grade nurses and auxiliaries for those on a higher grade. The principle focus of this paper is the evidence base on doctor-nurse substitution.

If substitution of lower paid staff for those who are higher paid is cost-effective, then real savings can be made by altering the skill mix. However, cost-effectiveness needs to be monitored; changes in relative earnings will affect the efficient (cost-effective) skill mix. Simply because nurses can do some tasks a doctor can do (and a lower grade nurse can carry out some of the tasks as well as a nurse of a higher grade), and because nurses earnings are lower, does not mean that it is cost-effective to substitute one for the other. Even if the outcomes are the same, the time taken to perform the tasks may differ significantly. If the nurses take much longer than a doctor to perform a particular task, then it may not be cost-

effective to employ nurses rather than doctors for these tasks. Therefore, policy makers ought not to consider solely the unit costs of labour, but use these in combination with outcome and data on time taken per task to identify the optimal skill mix.

Information on the ability of medical and nursing staff to substitute for each other together with the relative labour cost per task, is therefore vital for the policy makers. Many papers have been written addressing various aspects of skill mix and several have concentrated on the effectiveness and efficiency of substitution. While these papers provide a contribution to the evidence on substitution, there are a number of problems associated with the design and the data collection involved in these studies (see sections 1.2 and 4) which make their conclusions less than robust. These caveats about the generalisability of the results of studies of limited design and some age, should not be lost sight of by enthusiastic proponents of reform of skill mix in the NHS.

2. THE SCOPE FOR SUBSTITUTION: A REVIEW OF SUBSTITUTION STUDIES

2.1 Introduction

A necessary condition that must be met if doctors are to be substituted for by other health professionals is that the outcomes and the services provided by the substitutes are at least equivalent to those provided by physicians. A large amount of literature surrounds this subject (see for example Brown and Grimes (1993)), with the majority concluding that substitution is not detrimental to health outcomes.

This review of the literature is based on an extensive search of a number of databases (Appendix A contains a full description of the search strategy). Any review of the literature on doctor-nurse substitution should take account of the type of study employed in order to establish the effectiveness of an intervention (in this case replacing physicians with other health professionals). There is an established hierarchy for these studies, with Randomised Controlled Trials (RCTs) accepted as the "Gold Standard"; the type of study and the limitations of each study design should be remembered when considering the results presented

(a summary of this hierarchy from Woolf et al (1990), is presented in Appendix B). Few of the studies reviewed have a study design from which robust conclusions can be drawn.

2.2 A review of the substitution studies

The studies on the potential for substitution are presented in the following table. Each paper is described in more detail in Appendix C.

All of the studies concluded that substituting doctors with another health professional was feasible. The level of this substitution varies considerably and depends on whether potential or actual substitution was considered. Fottler (1982) found that only 4% of tasks in his study were delegated fully from a doctor to another health professional, though there was potential to increase this figure to 34%. At the other extreme, Ekwo et al (1979) found that over 80% of health care could be provided by a doctor substitute, while Rabin and Spector (1980) estimated that doctor substitutes could handle over 90% of tasks with some assistance. The majority of the studies concluded that the potential level of substitution was in the range 25% to 70%.

Each of the studies reviewed has some flaws. Several are due to the methodological difficulties described in section 1.2, others incorporate biases which limit the value of the study and its generalisability.

2.3 Conclusions

The studies reviewed here are few in number, often poorly designed (see Appendix B) and

are usually dated i.e. mainly from the 1970s and early 1980s. In addition, these studies are most often based in North America and usually in a primary care environment. They provide some limited evidence that at time, in those geographical locations and in the medical settings considered, there was potential for substituting other health professionals for doctors. However, attempting to apply these results to the UK at present would be misguided: this is an inadequate knowledge base from which to generalise about current practice.

Table 1. Review of studies on potential for doctor nurse substitution

Authors	Duration of trial	Location & Setting	Trial Design	Sample size	Providers	Primary Outcome Variable(s)	Cost data	Results/Conclusions
Gavett et al (1973)	2 months	Semi-rural area of New York. Private practice	Manpower model	419 visits	Physician Expanders	% of visits which could be delegated	N/A	This study concluded that 29% of visits could be carried out solely by PE. However, the results are dubious given the very small sample and diversity of physician responses.
Spitzer et al (1974)	12 months	Burlington, Ontario. General Practice setting	RCT	4325 patients (2796/1529 split)	2 MDs, 2 NPs	Patients health & satisfaction	Nurses provided services of \$16,000 value.	The small number of NPs in the study limit the results. The nurses managed 67% of visits without reference to the doctor. As the patients were not detrimentally affected, it is concluded that 67% of all doctor tasks performed in primary care could be delegated to nurses.

Table 1 (continued). Review of studies on doctor nurse substitution

Authors	Duration of trial	Location & Setting	Trial Design	Sample size	Providers	Primary Outcome Variable(s)	Cost data	Results/Conclusions
Levine et al (1976)	2 weeks	Maryland USA. Ambulatory setting	Cohort	2,234 visits	10 New Health Professional (NHPs), 12 MDs	Patient satisfaction	N/A	As the two groups were not matched the results should be treated with caution. Nevertheless, authors found that 68% of tasks are substitutable.
Ekwo et al (1979)	4 days	Iowa, USA. Satellite & non satellite	Cohort	1497 patients at 19 primary care sites	28 Physician Assistants (PAs)	None	N/A	PAs, or PAs in combination with nurses, provided over 80% of health care to patients seen, without need for MD supervision.
Rabin and Spector (1980)	2 weeks	Semi-rural area of US. Ambulatory care	Manpower Planning model	1,332 ambulatory contacts	Unspecified number of NHPs	% of tasks which could be delegated	N/A	NHPs could handle over 50% of primary care visits alone and over 90% with some assistance. Results are based on a small sample of visits and on physician's opinion, rather than on empirical analysis.

Table 1 (continued). Review of studies on doctor nurse substitution

Authors	Duration of trial	Location & Setting	Trial Design	Sample size	Providers	Primary Outcome Variable(s)	Cost data	Results/Conclusions
Record et al (1980)	Based on other trials	Based on other trials	Cost saving	N/A	MDs and NHPs	Outcomes from other studies	MD/NHP earnings, training costs.	Good study in itself, limited by data on which it is based. Cost savings can be made if substitution ratio > cost ratio
Fotler (1982)	N/A	Western New York	Postal questionnaire	1,786 eligible	All physician	% of tasks delegated, or could be delegated.	None	Only 4% currently carried out solely by extender, could be 34%. Results limited by unrepresentative physicians.
Denton et al (1983)	Based on other trials	Based on other trials; applied to Ontario	Cost study	N/A	GPs and NPs	N/A	Using evidence from other studies on potential for delegation (estimated at 30-80%), authors conclude that savings from implementation of NPs now would save 10-15% of total medical costs. Where introduction slower, and popn. changes accounted for, results are similar.	

Table 1 (continued). Review of studies on doctor nurse substitution

Authors	Duration of trial	Location & Setting	Trial Design	Sample size	Providers	Primary Outcome Variable(s)	Cost data	Results/Conclusions
Lomas and Stoddart (1985)	Based on other trials	Based on other trials	Sensitivity analysis using data from other trials	N/A	GPs and NPs	N/A	N/A	Based on other studies, and applying sensitivity analysis to a number of variables, 20-32% of primary care doctors could be replaced by NPs.
Salisbury and Tetersell (1988)	10 weeks	Reading, UK. General Practice setting	Cohort	1046 patients (210 NP, 836 GP)	One NP, One GP	Patient satisfaction	None	Small sample size and no follow up of non-responders weaken results. Could conclude that over 20% could be delegated, but dependent on emphasis within practice.
Knickman et al (1992)	3-4 days	2 teaching hospitals in New York	Time and motion study	8 resident doctors	8 resident doctors	N/A	N/A	The authors use two scenarios to estimate that the level of substitutability is 19-35%. This rises to 29-70% when time spent on patient care is only consideration.
Marsh and Dawes (1995)	6 months	1 group practice in Stockton, England	Cohort	696 consultations	One practice nurse	Reconsulting rate	None	86% of consultations for minor problems dealt with by nurse. Small sample of both nurse and consultations make conclusions weak.

3. THE SCOPE FOR SUBSTITUTION: A REVIEW OF THE COST-EFFECTIVENESS STUDIES OF SKILL MIX.

3.1 Introduction

Whilst evidence about the effectiveness of doctor-nurse substitution is necessary to inform skill mix choices, it is not sufficient. Any skill mix choice should be based on the evidence of cost-effectiveness if scarce labour resources are to be used efficiently.

There are few cost-effectiveness studies of doctor-nurse substitution. This may be due in part to the assumption of many practitioners and clinical researchers that, because nurses have in general, much lower earnings than doctors and that they can perform some of the tasks a doctor performs, skill mix alterations are necessarily cost-effective. This assumption may be incorrect for two reasons. First, no account is taken of the volume of activity; doctors could complete more tasks in a given period than other substituted health professionals, and that therefore the cost per task completed may be similar. Also, the cost of doctor supervision may not be accounted for or measured accurately. Secondly, doctors in the UK tend to be salaried and receive no overtime payments for overtime activities: nurses and other non medical (doctor) practitioners usually have a fixed working week (e.g. 38 hours) and overtime payments. These factors should be considered as the papers on the cost-effectiveness of substitution are now evaluated (these papers are summarised in Table 2, Appendix C).

3.2 A review of the cost-effectiveness studies

Studies of the cost-effectiveness of substitution are presented in table 2 below. A detailed description of each paper is presented in Appendix D.

Table 2. Review of cost-effectiveness studies on doctor nurse substitution

Authors	Duration of trial	Location & Setting	Trial Design	Sample size	Providers	Primary Outcome Variable(s)	Cost data	Results/Conclusions
Bureau of Health Manpower Phase 1	2 years	Portland, USA. Adult outpatient setting	Substitution model (with part C-E)	55 physicians, 5 PAs, 5 NPs	MDs, PAs and NPs	Cost savings	Cost of MDs and PAs	This large study concluded that \$20,000 saving per PA and a saving for the system of \$277,000 to \$485,000 were possible. Outcomes were not measured, but strict referral criteria employed to ensure MD seen if necessary.
Bureau of Health Manpower Phase 2 (1976)	2 years	Portland, USA. Adult outpatient setting.	Maximum substitution model (with part C-E)	55 physicians, 5 PAs, 5 NPs	MDs, PAs and NPs	Cost savings	Cost of MDs and PAs	This study, based on same population as Phase 1 (above) concluded that 16% of all MD costs could be saved by maximum substitution of PAs for MDs.
Schneider and Foley (1977)	N/A	N/A	Manpower planning model*(+ part C-E)	N/A	Physician and NPPs	N/A	Cost ratios of MDs vs PEs were considered	This study estimated that a 4% cost reduction and a 40% physician reduction could be achieved with extensive use of PEs. However, no outcomes measured.

These studies attempt to estimate the levels of various labour inputs which either are required or would be required under a given set of circumstances.

Table 2 (cont). Review of cost-effectiveness studies on doctor nurse substitution

Authors	Duration of trial	Location & Setting	Trial Design	Sample size	Providers	Primary Outcome Variable(s)	Cost data	Results/Conclusions
Hansen et al (1980)	49 weeks	University Health Clinic (primary care provider) in US	Cost minimis (though claims to be cost-effective)	3 PAs and 1 NP	PAs and NP	None	Salary costs of physicians and PEs	Physician Extenders are shown to be cost-effective in student health settings but not in a family practice setting. Also PEs can provide 60-80% of patients in such settings. However, results are dubious as outcomes ignored and only a small number of providers were considered.

3.3 Conclusions

In general, there are less biases involved in the cost-effectiveness studies than in the substitution and delegation studies, though this is partly due to the assumption that outcomes are equivalent rather than using patient satisfaction which is open to responder bias.

Evidence on the cost-effectiveness of substituting other health professionals for doctors or physicians is limited. The K-P (1976) study indicates that savings could be made, but assumes rather than demonstrates equivalent outcomes. The study by Schneider and Foley (1977) indicates that substitution is cost-effective as long as the salaries of the substitute providers remain considerably below (less than half) the salary of the physician. As with the effectiveness studies, the literature about the cost effectiveness of alternative skill mixes is US based, and dates from the 1970s. Its usefulness as a knowledge base to inform current skill mix choices anywhere in the world is very limited.

4. SOME GENERAL ISSUES ARISING FROM THE LITERATURE

In a variety of settings (though most often in primary care) some tasks may be performed by nurses (or other health professionals) at a level comparable with that provided by the doctor/physician. For instance Buhler et al (1988) show that nurse midwives provide care that is at least equal to Family Practitioners. Hollis et al (1993) used an RCT design to show that counselling of smokers by nurses was superior to counselling by physicians. The results of the available studies suggest that between 30% and 70% of doctors tasks could be carried out by nurses. However, most of these studies suffer at least one common weakness and lack external validity.

There are several recurring weaknesses in the studies reviewed, the most common of which are:

- i) many of them are at a single site.
- ii) many of the studies use very small sample sizes from which it is difficult to make robust inferences.

- iii) the standard design does not involve randomisation: most studies use either cohort or before and after design.
- iv) few studies use adequate measures of health outcome.
- v) any outcomes measured were evaluated in the short-term, thus any adverse (or positive) effects occurring in the medium to long term are ignored.
- vi) the other health professionals selected to participate in studies as substitutes for doctors are likely to be unrepresentative; they are more likely to be above average in terms of ability, dedication and perhaps training.
- vii) the majority of them ignore costs or use a very narrow range of costs (for example only considering salary).
- viii) the majority of studies are North American and dated; this causes difficulties when attempting to generalise results to the current situation in the UK.

The cost-effective level of substitution is dependent on the cost ratio between the various health professions. The points listed below contribute to the cost-effectiveness (or otherwise) of other health professionals including nurses.

- i) Are outcomes the same or simply assumed to be the same?
- ii) The time taken for particular tasks and the number of patient visits by NHP versus physicians (i.e. productivity) may vary.
- iii) What is the degree of supervision of NHPs by physicians?
- iv) Are NHPs actually or potentially cost-effective; will the results of trials be replicated in practice or was the trial carried out under different circumstances?
- v) Is remuneration of NHPs and physicians static? What happens when overtime activities and payments are considered?

5. SOME IMPLICATIONS OF CHANGES IN SKILL MIX

5.1 Skill mix changes in general practice

The majority of the literature on doctor-nurse substitution is concerned with primary care settings; thus the doctor is invariably a General Practitioner (GP). The implications for GPs

could be profound. The study by Lomas and Stoddart (1985) suggested that between 20-32% of GPs could be replaced by other health practitioners. If this were applicable to the England, this would result in a fall in the number of GPs from around 27,500 in 1990 (Bloor and Maynard (1993)) to as few as 18,700. This would save approximately £300 million per annum if nurse practitioners were substituted for GPs, and if such a policy could be implemented quickly (see Appendix E). Such a policy would reverse the trend for the number of GPs in England, which increased from 23,674 to 27,523 (16.2%) between 1980 and 1990 (Bloor and Maynard 1993); this would represent a fall from approximately one GP per 1750 population in 1990 to one GP per 2600 population. Such a solution would contradict the advice of the Medical Manpower Standing Advisory Committee (MMSAC), who propose a GP to population ratio of 1 to 1,700 by the year 2010. The basis for this ratio is absent and such a policy could lead to surpluses in the supply of physicians in the next century (Maynard and Walker (1995)).

The issue of physician surpluses is topical in the US with Weiner (1994) forecasting that by the year 2000 there will be a surplus of approximately 165,000 physicians, primarily specialists. Steinwachs et al (1986) have argued that the physician surplus would be reduced if the funds available to train physician substitutes are decreased, implying that there is a degree of substitution between the professions.

The potential savings from such a policy may be reduced when overtime activities are included. GPs receive, on average, 60% of their income from capitation. A number of extra payments can be made to GPs (for example out of hours). Nurses are recompensed for overtime, and this will usually be at a higher rate than average, though a differential between nurses and GPs would be maintained as long as the nurse does not receive more than three times their standard hourly rate for overtime.

5.2 Implications for Nurses, Nurse Practitioners and other Health Professionals.

Changes in skill mix and the pressure for efficiency gains have made nursing more "pressured" according to professional opinion and casual empiricism. Changes in training,

increased "professionalism" and this increased "pressure" may lead to increases in the relative pay of nurses. Such changes would alter the cost-effectiveness ratio. In the United States, Elias reports (Elias 1995) that "unlicensed aides are suturing in surgeries. Aides now inject IV drugs into cardiac patients at UCLA Medical Center". The management of cash-limited NHS Trusts and primary care facilities may be tempted to emulate such trends in the UK to mitigate the cost pressures created by the nursing expenditure constraints i.e. nurse/assistant substitution may be exploited to reduce the demand for nurses. The number of nursing and midwifery staff in the UK has already dropped from a high of 510,900 in 1989 to 477,600 in 1993 (Office of Health Economics 1995) with further falls expected. One cause of this poorly measured and unevaluated trend may be substitution of nurses by assistants.

5.3 Implications for patients

Can nurses provide a service that is at least as good, in quality terms, as that provided by the doctors? The cost-effectiveness of substituting nurses for doctors cannot be demonstrated without the measurement of the quality of the services provided. Measurement of patient outcomes was neglected in the studies carried out in the US in the 1970s and 1980s and it is essential that such evaluation is used to inform any policy. Until such research has been completed, the effects on patient health and well-being are unknown.

5.4 Overview

The implications of doctor-nurse substitution cannot be accurately determined until more research has been carried out. If there is an increase in the status of nurses in the short-term this may be accompanied by financial rewards which would alter the cost-effectiveness of NPs. This tendency may be complemented by the development of degree level nursing, though this would enhance nurse-care assistant substitution in primary and hospital settings. The substitution of cheaper (lower grade) nursing staff for more expensive staff may affect the quality of care. Carr-Hill et al (1995) comment "that the higher the grades (and skills) of the nurses who provide care, the higher the quality of care".

6. CONCLUSIONS

To estimate the level at which doctors can be substituted with nurses in the UK would require a randomised controlled trial with careful measurement of costs and patients' outcomes and an adequate follow-up period. As Spitzer (1984) pointed out "the expense and complexity of properly controlled trials and well-designed follow-up studies have inhibited their replication in sufficiently diverse settings to ensure that conclusions about safety and efficacy can be generalised". However, these costs may be small when compared to the potential savings available by substituting nurses for doctors and the potential costs (including damage to patients) of changing skill mix "on the hoof" and in the absence of a sufficient knowledge base. It is inefficient, but usual, for the NHS and other health care systems to alter skill mix and pay little regard to the evaluation of such policies.

The US literature suggests that the substituting nurses for doctors in some tasks appears to be cost-effective and that a significant percentage of tasks, possibly between 30% and 70%, could be carried out by doctor substitutes. This literature dates mainly from the 1970s and 1980s and some of the potential for substitution may already have been exploited, thus the potential for substitution has probably fallen. In contrast, the UK literature is limited. Despite this lack of evidence in the UK, and probability that the US evidence is not generalisable to the UK, substitution has occurred to a significant degree in the NHS. In all countries the cost-effectiveness of substituting nurses for doctors is constrained by the labour contract: nurses work fixed working weeks with paid overtime, whilst senior doctors do unpaid overtime and are usually quicker dealing with patients. If nurses refer large numbers of patients to the GP for instance, the savings of substitution will be eroded considerably.

Yet substitution is taking place. The number of whole time equivalent practice nurse posts has increased from around 3,000 in 1988 to over 9,000 in 1992 in England and Wales (Atkin et al (1993)). To ensure that further expansion of other health professionals as substitutes for doctors (with the likely effects on doctor numbers and GP to population ratios) is optimal this substitution should be demonstrated to be cost-effective; otherwise the manpower available within the NHS will be employed inefficiently.

Fewer doctors? More nurses? The answers to these questions appears to be "yes" in terms of practice in the US. In both the US and the UK there also appears to be changes in the use of assistants, aides, counsellors, and other types of skill. The managed care organisations in the USA are saving considerable resources by altering the skill mix. Such changes may be easier, and have fewer effects on outcome, in well financed health care systems such as the United States. The evidence base to support the employment of fewer doctors and more nurses, even for the US where most of the studies have taken place, is poor.

Radical changes appear to be taking place in skill mix practices in the UK even though this cannot be justified from the literature. If changes in the skill mix are introduced it is to be hoped that, unlike previous doctor-nurse skill mix changes, these substitution policies will be evaluated to demonstrate their cost-effectiveness. It is unfortunate that decision making in this area of health care policy, as in others, is not "confused" by the results of well designed evaluative studies.

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APPENDIX A

This report has been compiled using an extensive search of the literature on doctor-nurse substitution. The MEDLINE database was searched from 1970 to present and the CINAHL (Cumulative Index to Nursing and Allied Health Literature) database searched from 1982 onwards. DHSS-Data was also examined from 1983 onwards. The Excerpta Medica database was searched without date limits. Key terms included in the search strategy included physicians, physicians assistants, physician extenders, nurse practitioners, nurse anesthetists, nurse midwives, triage and substitution. Other relevant, and earlier, references from the articles retrieved were followed up. Studies which included any data or estimates of the potential for substitution either of tasks or personnel were reviewed.

APPENDIX B

Hierarchy of evidence:

I Well designed randomised controlled trial

II-1 Other types of trials:

Well-designed controlled trial without randomisation

Quasi-experiments

II-2 Well-designed cohort (prospective) study, preferably from more than one centre.

II-3 Well-designed case-control (retrospective) study, preferably from several centres.

III Large differences from comparisons between times and/or places with or without the intervention

IV Opinions of respected authorities based on clinical experience; descriptive studies and reports of expert committees.

Source: Woolf et al (1993)

APPENDIX C

1. Gavett et al (1973)

The authors examined a sample of 419 visits between April and June 1971 to a group practice (of 10 physicians) in a small city in New York state. The authors estimated that 29.1% of primary care tasks could be completed by physician expanders without consultation with the physician. However, the authors acknowledge several potential weaknesses of the survey. Firstly, there is no test for reliability in the physicians responses (that is whether they would answer the same if presented with the same set of conditions). Secondly, there was a large amount of disagreement between the physicians concerning the potential for delegation; a much larger sample of physicians and physician expanders would be required to achieve a robust result. In addition, only five of the 10 physicians were included and the selection criteria were not listed. The potential delegation of 29.1% of visits was based on only 32 visits between the five physicians; 14 of these were from one physician. The very small number of visits considered makes it difficult to make firm conclusions.

2. Spitzer et al (1974)

One of the first trials located examining the possibility of substituting doctors with other labour inputs was the Burlington Randomized Trial carried out in 1971 and 1972. The results of this trial were reported by Spitzer et al (1974). The trial was based on two family practices in Burlington, Ontario which were "saturated" (i.e. could not receive additional patients). The physicians in these practices believed that the office nurses, with additional training, were capable of dealing with a substantial proportion of primary care responsibilities. Consequently, 540 families were randomly allocated to be treated by the two nurses, with the remaining 1058 families being seen by the two doctors. The patients in the two groups were similar in physical functioning and showed no significant differences in base line health status, though the age/sex distributions of the two groups was not discussed. There was no blinding involved, as presumably the patients recognised the personnel.

The results of the trial showed that there were no significant differences between the groups in terms of health outcome (measured by the management and outcome of 10 indicator conditions, and by the manner in which drugs were prescribed), nor in the patients satisfaction with the service they received. It was estimated in the study that in 67% of cases, nurses were able to deal with patient visits independently of the physician and without any detrimental effects on patients health, or the service they received. It was concluded that this level of delegation could safely be carried out in this primary care setting. A potential weakness of this otherwise well conducted study, is the small number of NPs considered. With such numbers the potential to select more able or enthusiastic staff is increased. In addition, the trial suffers from "unit of analysis" bias. The unit of measurement should be the provider rather than the patient, so that the outcomes of all patients are in some way aggregated and the provider is thereby evaluated. Despite these weaknesses, this remains one of the most important studies in this field.

3. Levine et al (1976)

This study examined practice patterns and self reported patient health outcomes for 10 physicians and 12 NHPs in a predominantly white, middle class area of Maryland, USA in 1974. The health care delivered in this ambulatory setting comprised well person care, adult medicine and paediatric medicine. The study compares the two groups (those treated by the NHP and those treated by the physician) using a questionnaire prior to treatment, a questionnaire for providers to complete in 50% of cases followed by a one week telephone follow up for a random 50% sample, and a one month postal follow up for any patients with "medical problems". The major variables measured in the follow up were problem status, satisfaction and reported compliance; accessibility, initial problem status and attitude towards providers were collected on the original questionnaire. The questionnaire completed by the providers asked for information on the tasks performed, how the provider interacted with the patient and the expected outcomes.

Response rates were high; 87% for the pre-treatment questionnaire, 81% for the one week telephone follow-up and 87% (after telephone reminder) for the one month follow-up. Responder bias, that is the possibility that in some significant way those who respond are different from those who do not respond, was tested for and was found to be insignificant in most cases.

The authors found that 68% of appointments with NHPs ("health associates" in this instance) did not involve a physician in any way, though this varied across specialties. As 36% of the appointment made at the clinic are with the NHPs, it follows that 22% of all clinic visits were handled independently of physicians.

The results of the health outcome measurements are difficult to interpret due to the groups not being matched. For instance, it is possible that the NHPs saw patients whose condition was more likely to become less painful after a month (regardless of treatment) than did the physicians. Thus outcome data showing that those treated by the NHPs improved more over the month than did those treated by the physician are unreliable. In fact the results show no significant difference at the one month follow up for paediatrics but outcomes were better for the NHP providers in adult medicine; the authors acknowledge that this is likely to be due to the case mix faced by physicians. Few significant differences were found in the levels of patient satisfaction, although where they do exist, physicians are favoured.

Unfortunately, while the results in terms of the proportion of tasks which can be substituted (nearly 70%) reflect those reported in Spitzer et al (1974), in this study the patient groups treated by the two types of provider are different. In addition, the treatment groups are not matched so that conclusions on the quality of care are tentative.

4. Ekwo et al (1979)

The authors used a cohort study to evaluate the level of supervision given by MDs to PAs at satellite (i.e. remote from the primary practice) and non-satellite sites (i.e. the MDs primary place of practice). The study was situated in Iowa and was based on 19 sites and 28 PAs, who had assistance from a nurse. A further 17 PAs were eligible for the study but either did

not consent to participate or did not take part for some other reason. It is possible therefore that there was some "participation" bias in this study. The PAs who were willing and able to participate could possess significantly different characteristics to those who did not take part; for instance, it is possible (or even likely) that the more "able" PAs entered the study. These factors affect the external validity of the study, in that they are unlikely to reflect usual practice, and therefore the promising results are unlikely to be reproduced if put into a "normal" situation.

The groups treated at the different sites were not randomised so that conclusions on the level of supervision are open to question. However, the authors found that 84.5% of patients seen in the satellite practices and 87.1% of patients in the non-satellite practices received their health care without the supervising MD i.e. from the PA alone or the PA in conjunction with the nurse. The PAs spent longer on average with patients than MDs at both types of site, though there were wide variations. The authors did not estimate the percentage of tasks or office visits this represented. Because of the problem with participation bias, and the lack of measurements of health outcome, no firm conclusions can be made regarding the level of safe substitution.

5. Rabin and Spector (1980)

The authors used a prospective study to estimate the potential for delegation in primary care. The study was conducted over a two week period in 1974 on a semi-rural population in the US which was deemed to be representative of the US apart from in the racial mix. 1,332 contacts were studied, and a panel of six physicians who worked with or trained NHPs estimated the amount of responsibility that an NHP could take in each instance (i.e. the level that could be delegated).

The authors estimated that depending on the type of NHP considered, between 40.1% and 53% of primary care visits could be handled solely by the NHP and that in more than 90% of these visits the NHP could be usefully employed. The major problems with this survey were that the number of visits was small and the time frame was narrow. In addition, the assessment of the percentage of tasks which could be delegated to NHPs was carried out by a small number (six) of potentially biased physicians, rather than on any empirical analysis. Health outcomes were not considered.

6. Record et al (1980)

Record et al (1980) carried out a review of the literature to establish the potential level of substitution of NHPs for physicians in primary care facilities in the US. The authors included many of the (obviously pre-1980) studies described above and generously claimed that "the quality of research in most of the studies ... is good" though acknowledging the obvious weaknesses of some papers and the consistent biases throughout the literature on this subject. Record et al (1980) went on to conclude, using these studies, that the substitution ratio between physicians and NHPs was 0.63 (i.e. 1 NHP is equivalent to 0.63 physicians). This is then compared with other studies where the rate is estimated at between about 0.53 and 0.76.

The authors argue that if the substitution ratio is greater than the cost ratio (of employing and training of physicians and NHPs), then NHPs are cost-effective. Thus if the substitution ratio is 0.6 and the cost ratio is 0.3 (so that one NHP can provide the identical services provided by 0.6 of a physician, but at 0.3 times the cost), then clearly the NHP is cost-effective.

There are some problems with the analysis mainly linked to the flaws in the studies upon which the analysis is based. These papers rarely consider outcomes and for cost-effectiveness of NHPs to be rigorously demonstrated, the outcome of treatment by NHPs (in terms of health, well-being etc.) must be the same or higher than that of physicians. Although a meta-analysis of studies on nursing in primary care environments concluded that for NPs and Certified Nurse Midwives "patient outcomes [were] equivalent to or slightly better than those of physicians" (Brown and Grimes (1993)), this should be treated with some caution as only 12 of the 38 identified studies used an experimental design and randomised patients to providers.

While many studies mention effectiveness, this has not been established to a satisfactory level. Reports of the effectiveness of particular interventions need to be closely scrutinised; the weakness of data on which such conclusions are based needs to be recognised and any potential biases acknowledged (see Freemantle and Maynard 1994).

Cost savings in this scenario are influenced by the US health care system where NHPs are salaried but physicians tend to receive "entrepreneurial income". In the UK, physicians (GPs in most cases relevant to this subject) are more likely to be salaried, though opportunities to increase income exist. It is improbable that such results can be generalised to the UK.

7. Fottler (1982)

Fottler (1982) used a mailed questionnaire survey to estimate the level of task delegation as well as potential task delegation in Western New York in New York state. All members of the local medical society were included in the mailing (n=1,914), but after retirements, deaths and changes of location, only 1,786 eligible physicians remained. Of these, 724 (40.5%) completed the questionnaire. This response rate and the associated risk of responder bias is acknowledged by the author, together with the fact that the responding physicians were older than the average for the area. However, this leads to a weakening of confidence in the results.

The author found that the actual level of delegation was low, around 4% of "typical tasks" were performed by physician extenders and around 11% of the same tasks would be jointly managed. If well trained extenders were available, however, the physicians indicated that 34% of tasks could be delegated. The reservations expressed above suggest that these results may not be generalisable.

8. Denton et al (1983)

Denton et al used evidence from other trials in an attempt to place these transition costs in perspective. The authors employed a costing study to estimate the potential savings attainable

by implementing a doctor-nurse substitution policy in Canada. The study considered a primary care setting and was based on substitution which has been shown to be delegable rather than having the potential to be delegated. Thus the estimates in this study are likely to be conservative.

The model used by the authors divided costs into groups; those associated with births and non-birth related costs and those concerned with ambulatory and non-ambulatory services. The justification appears to be that the very young and the old are the highest users of health care and that the number of very young is reflected by the number of births. It is assumed that the ratio of NP salary to GP salary remains constant over time. The authors use sensitivity on a number of pivotal variables i.e. the ratio of time taken by NP to complete a task compared to a GP, the proportion of time spent in non-birth-related cases in the various age-sex categories and the birth-related proportions in the child-bearing age categories. Future fertility levels, mortality levels and utilisation of NPs once they have been introduced are also varied. The level of delegation is varied from 30% to a high of 80% across the age and sex groups. Delegation here, is not considered in terms of tasks but rather in terms of time.

The authors estimate that if NPs could be fully implemented and utilised instantaneously, that a saving of 10% of the cost of all medical services could be made. These conclusions do not alter substantially even when the period of implementation is extended, or the demographic distribution of the population changes appreciably. These savings must be weighed against the adjustment costs of introducing NPs on a wide scale and should also be viewed in the light of legal and political barriers to implementation of NP policy. However, the methodology of this paper appears sound and while occasional parameters may be based on data of limited quality, the conservatism of some of the assumptions is likely to offset this and back up the conclusions.

9. Lomas and Stoddart (1985)

This study was based on other trials and performed sensitivity analysis to estimate the impact of NPs on general practice settings. The authors report that between 40% and 90% of primary care physician tasks could be safely delegated to nurse practitioners. These figures are based on a number of studies/reviews described in this paper (the review by Record et al (1980), and the studies, by Denton et al (1983) and Spitzer et al (1974)). Using these sources, as well as the "opinion of doctors and nurses" (neither the numbers of doctors and nurses consulted nor the selection criteria were reported in the paper), this review then considered separately the levels of delegation by age and sex as there are different potentials for delegation. The authors allowed for the fact that delegated tasks are likely to be the simpler tasks (though this becomes progressively less so as more tasks are delegated), as well as acknowledging that physician supervision will be required for some tasks. The authors concluded that, either instantaneously or over a period of years, between 20-32% of GPs could be replaced with NPs without any detrimental effects on patients' health or well-being.

10. Salisbury and Tattersell (1988)

The issue of doctor-nurse substitution has more recently become topical in the UK. As a result of this the literature is more recent than that in the US, though it is limited to a few

papers. This is a study influenced by, but acknowledging the substantial deficiencies of, the work of Stilwell et al (1987) (for instance there was only one practice nurse in the study and patients outcomes or satisfaction were not measured). This cohort study was set in a general practice setting in the UK during a ten week period in 1987. The patients seen were not randomised, rather they chose to see either the GP or the NP who were equally available.

In total 210 patients were seen by the NP, resulting in 322 consultations and 365 problems seen. In the same period the comparator doctor saw 836 patients with 1239 problems in 1115 consultations. To measure patient satisfaction, 100 questionnaires were distributed to a proportion of those who had been seen by the NP; 73 were returned. Of these, 70 were very satisfied with the consultation and the others were satisfied. While this is a very small sample, and there is potential for responder bias (those who were more satisfied may be more likely to return the questionnaire), in this setting it seems reasonable to conclude that patients were happy with the care they received; however, it does not follow that the standard of care, nor the health outcomes associated with this care are the same. Therefore the nurses provided 22.4% of consultations without any apparent patient dissatisfaction; this percentage is a measure of the actual level of delegation in this practice, the potential level of delegation could be higher. However, no conclusion can be made regarding the safety of such delegation until more substantial health-related outcomes are included in a new study.

The conditions treated by the NP were different from that of the GP; notably NPs provided a much higher percentage of preventive care and health education than did the doctor. Thus the extent to which NPs can substitute for doctors depends on the emphasis given to these services. As the authors earlier acknowledged that the GPs in the practice have a commitment to these two services, this may increase the level of substitutability in this practice, but may make the results ungeneralisable to the rest of the UK.

There are several other problems with this study; the sample sizes reported are small, one NP compared with one doctor and patient satisfaction based on 73 responses and no follow up of the none responders. In addition, again the one NP may be completely atypical; whether any or all NPs could perform these tasks is not answered. Given these reservations, the results must be treated with caution.

11. Knickman et al (1992)

The authors used a time and motion study set in two urban hospitals in New York in 1988 to examine the potential for substitution in teaching hospitals. The authors use data collectors to observe how residents spend their time and subsequently decide using a panel of "experts" from a cross-section of disciplines to decide how much of this is substitutable; there is a considerable degree of subjectivity involved at this stage. The authors estimate that between 19-35% of residents time is spent on activities that could be done by some other health practitioner. The lower figure is based on the traditional model of care used at the time in US inner city teaching hospitals; the higher figure reflects what is likely to happen if a "mid-level" practitioner (such as an NP) co-ordinates the patients' care.

The results of this study appear to show a low level of potential substitution relative to other studies. However, included in the analysis of the residents' time is their personal time and

their educational time, both of which are judged to be non-substitutable. Once these activities have been discounted so that only time spent caring for patients is included, the percentages that are substitutable rises to between 29-70% (these figures have to be calculated, they are not reported in the paper).

This study was carried out in a teaching hospital setting and the results may not be generalisable to the rest of the US let alone the UK. The sample size of eight residents is also very small and makes the results more questionable, as does the largely subjective measurement of which tasks can be delegated to non-physicians. However, the level of substitutability of time, once allowance is made for personal and educational time, is not inconsistent with other similar studies.

12. Marsh and Dawes (1995)

The authors consider the feasibility of a practice nurse providing care for patients with minor illnesses in a general practice setting. The results show that 86% of consultations (for minor illnesses) can be handled by a practice nurse without consultation with the doctor.

The authors also found that reconsulting rates were not particularly high (nearly 80% of patients did not reconsult for the same condition within two weeks), though this is not compared with the reconsulting rates of the GPs.

However, the study is based on one general practice setting and only 696 consultations over a six month period. In addition, the practice nurse is unlikely to be representative of the nursing population so that generalisability becomes a problem. There were three practice nurses in the practice and it is unclear how this one was selected. Finally, there was no medium or long term measure of health outcome.

APPENDIX D

1. The Kaiser-Permanente (K-P) Medical Care Program, authors Bureau of Health Manpower (1976).

This study, carried out between 1966 and 1972 and encompassing two separate phases, was based in an adult primary care setting in Portland, Oregon, in the Department of Medicine. The Department consisted of 55 physicians, 5 PAs and (from 1975) 5 NPs. The study consisted of two phases; the first phase estimated the actual and potential savings available in the K-P system using the substitution model employed at the time. The second phase commenced in 1973 and considered savings which could be made if substitution were pushed to its maximum level.

In Phase 1, it was found that the MD/PA substitution ratio was between 0.4 and 0.76 depending on length of working week and degree of triage. This resulted in savings of at least \$20,000 per year per PA and total savings in the system of \$277,000 to \$485,000, though these would be constrained by legal barriers.

Phase 2 of this study was concerned with the maximum level of substitution between physicians and PAs; it is not however, a cost-effectiveness study as it may not be cost-effective to implement substitution to the maximum level. Health outcomes are not measured, but are assumed to be identical. A rigorous protocol was set up to ensure that physicians would always be consulted when required. Despite not being a cost-effectiveness study, evidence for the cost-effectiveness of the model is presented so that comparisons with Phase 1 of the study could be made.

Predictably, given the nature of the model, Phase 2 of this study resulted in greater savings than did Phase 1, though different methodologies make direct comparison difficult. In Phase 2, 16% of all MD costs could be saved whereas in Phase 1 this figure was 14% (the absolute figures also show a greater saving, but are of little value as the bases, the MD costs, changed considerably throughout the study period). As with Phase 1, however, any savings may be constrained by legal barriers and/or the preferences of physicians. One potential problem with the study is the generalisability of the results. The very fact that these physicians allowed study of their services and how they could be substituted for cheaper (and yet implicitly equally effective) PAs, may make them significantly and fundamentally different from physicians as a whole.

2. Schneider and Foley (1977)

The authors used a manpower planning model to analyse the levels of required manpower and associated costs in an ambulatory care environment. Three objective functions were considered; minimising the cost of the clinical operation, minimising the number of physicians employed in the clinic or maximising the number of patients that can be cared for in the clinic. These objectives were maximised or minimised subject to constraints placed on available personnel, space and finance. The model developed was tested for internal, face, subsystem, time-series and data validity and was also subjected to sensitivity analysis and parametric testing (i.e. so that parameters used were reasonable).

The authors found that based on a service population of 82,000, the cost per person per year was reduced from \$44.95 to \$43.36 (or 3.5%) if Physician Extenders (PEs) were used. The number of physicians required fell substantially from 33.21 to 20.17 (a fall of 39%). The authors do not state the number of PEs required, merely that PE use would have to be "extensive", to allow these manpower reductions, therefore it is impossible to say what how "substitutable" PEs and physicians are.

Schneider and Foley (1977) also considered the consequences of changing the relative salaries of PEs and MDs; they found that increasing the cost ratio to 0.475 resulted in independent PE roles ceasing and at 0.525 the only use for PEs would be in preventive medicine and emotional treatment. This would seem to suggest that as the cost ratio approaches and exceeds 0.5, the cost-effectiveness of PEs is limited.

3. Hansen et al (1980)

This study of the cost-effectiveness of physician extenders was carried out over a 49 week period in 1977. Three PAs and one nurse practitioner formed the group of extenders who worked in a primary care practice based in a large university. There were two clinics involved in the study, a Student Health Clinic (used by the students), and a Family Practice clinic (open to the whole community).

The authors assumed, rather than demonstrated, that the health outcomes and the quality of care were identical for the patients treated by the physician or by the physician extender. The "cost-effectiveness" therefore becomes a measure of quantity treated versus the cost of treating, and may be more accurately described as a cost-minimisation study (though even this could be questioned as the quality of the papers on which the assumption of equivalence of outcome between practitioners is based are generally poor).

The authors found that in the Student Health Clinic (SHC), the extenders saw nearly 80% of students alone whereas in the Family Practice Clinic (FPC) this fell to around 60%. The resulting effect on the cost-effectiveness was that in the SHC the cost per client visit was \$8.53 for the physician and \$5.49 for the extender. In the FPC, the cost per client visit was \$9.35 for physicians and \$9.15 for extenders. Thus extenders were deemed to be cost-effective in the SHC setting but not in the FPC setting.

As well as the fact that outcomes were not measured in any way, it was also assumed that the only significant cost factor was salary; this may be inaccurate. These results may also suffer from a lack of generalisability, especially to the UK where student health clinics have a relatively small role to play in primary care.

APPENDIX E

GP salary = £43,165 (Financial Pulse 22/2/95)

Nurse salary is a weighted average of the midpoints of nursing grades A to I. The midpoints and the numbers on the scales are taken from the Review Body for Nursing Staff, Midwives, Health Visitors and Professions Allied to Medicine Report. The salaries considered are only those on Grades A to I; thus students etc. are discounted. The percentages making up these groups are thus derived percentages as the groups make up only 90.4% of nursing staff; therefore the percentages shown in the Report are adjusted upwards. It is calculated thus:

Average nursing salary = £8,185 (midpoint Grade A) x 22.6% (percentage on grade A)

+ £9,340 (B) x 6.2%

+ £10,665 (C) x 3.5%

+ £12,230 (D) x 19.5%

+ £13,990 (E) x 21.8%

+ £15,795 (F) x 8.0%

+ £18,445 (G) x 14.7%

+ £20,480 (H) x 2.8%

+ £22,570 (I) x 1.1%

= £13,034

Allowing 20-25% on-costs, the difference between GP and nurses costs is either (£43,165 x 1.2) - (13,034 x 1.2) OR (£43,165 x 1.25) - (£13,034 x 1.25)

= £36,157 to £37,664

As 8,800 GPs would be replaced by nurses this results in a saving of between 8,800 x £36,157 and 8,800 x £37,664

= £318 million to £331 million

The above implicitly assumes that any nurse could be substituted. In reality a practice nurse is likely to be substituted; practice nurses would be on Grades D to H. A more realistic assessment of the potential savings would be based on the salaries attached to these nursing grades. Thus:

$$= £12,230 \times 29.2\%$$

$$+ £13,990 \times 32.7\%$$

$$+ £15,795 \times 11.9\%$$

$$+ £18,445 \times 22.1\%$$

$$+ £20,480 \times 4.1\%$$

$$= \underline{£14,942}$$

Thus savings are between:

$$8,800 \times [(£43,165 \times 1.2) - (£14,942 \times 1.2)]$$

and $8,800 \times [(£43,165 \times 1.25) - (£14,942 \times 1.25)]$

$$= \underline{\underline{£298 \text{ million to } £310 \text{ million}}}$$

These figures are summarised in the following table:

Table 2: savings available through substituting nursing staff fro GPs.

Type of nurse substituting for doctor	Minimum Saving (on-costs of 20%)	Maximum Saving (on-costs of 25%)
Any nurse of grade A to I	£318 million	£331 million
Nurse of grade D to H	£298 million	£310 million