Acute viral infections of upper respiratory tract in elderly people living in the community: comparative, prospective, population based study of disease burden

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Abstract

Objective: To evaluate the disease burden of upper respiratory infections in elderly people living at home.
Design: Prospective surveillance of elderly people.
Intervention: None.
Setting: Leicestershire, England
Subjects: 533 subjects 60 to 90 years of age.
Main outcome measures: Pathogens, symptoms, restriction of activity, duration of illness, medical consultations, interval between onset of illness and medical consultation, antibiotic use, admission to hospital, and death.
Results: 231 pathogens were identified for 211 (43%) of 497 episodes for which diagnostic specimens were available: 121 (52%) were rhinoviruses, 59 (26%) were coronaviruses, 22 (9.5%) were influenza A or B, 17 (7%) were respiratory syncytial virus, 7 (3%) were parainfluenza viruses, and 3 (1%) were *Chlamydia* species; an adenovirus and *Mycoplasma pneumoniae* caused one infection each. Infections occurred at a rate of 1.2 episodes per person per annum (95% confidence interval 1.0 to 1.7; range 0-10) and were clinically indistinguishable. Lower respiratory tract symptoms complicated 65% of upper respiratory infections and increased the medical consultation rate 2.4-fold (χ^2 test $P < 0.001$). The median interval between onset of illness and medical consultation was 3 days for influenza and 5 days for other infections. Rhinoviruses caused the greatest disease burden overall followed by episodes of unknown aetiology, coronaviruses, influenza A and B, and respiratory syncytial virus.
Conclusions: Respiratory viruses cause substantial morbidity in elderly people. Although respiratory syncytial virus and influenza cause considerable individual morbidity, the burden of disease from rhinovirus infections and infections of unknown aetiology seems greater overall. The interval between onset of illness and consultation together with diagnostic difficulties raises concern regarding the role of antiviral drugs in treating influenza.

Introduction

Excess deaths have consistently been shown in elderly people during the winter and have largely been attributed to influenza and low temperature.[1] Until recently the possible contribution of respiratory viruses other than influenza has attracted little attention. During winter 1988-9 we observed the cocirculation of various respiratory viruses, including influenza, in homes for elderly people in Leicestershire.[2] The illnesses were indistinguishable and were associated with lower respiratory complications and deaths. We speculated that the burden of respiratory viruses other than influenza was considerably underestimated. As remarkably little is known about respiratory viral infections in elderly people living at home, we prospectively evaluated upper respiratory infections in such people in Leicestershire over two winters.[3]

Subjects and methods

Population and study

The study was conducted among people aged 60 years and older during the winters of 1992-3 and 1993-4 in Leicestershire.[3] During April to June 1992 we sent letters to 800 of the 129 000 people aged 60 years and older who lived in Leicestershire inviting them or their spouses, or both, to participate in the study; the sample was randomly selected by the family health services authority computer. We received 617 responses including 52 that were returned unanswered because of incorrect address, death, or disinterest. A total of 441 subjects were recruited when the study began in 1992. Ninety four of the 441 subsequently died, deteriorated, or declined to take part during 1993-4, and an additional 92 subjects were recruited in 1993 from the original respondents. Patients living in residential care were excluded. Basic demographic data, medical and drug history, and nose and throat swabs were collected at recruitment. During surveillance periods each subject was contacted weekly by telephone at a prearranged time. By using a questionnaire, volunteers were asked whether an upper respiratory infection had occurred during the previous week. When illness was reported, a record was made of date of onset, symptoms,[3] incapacitation, medical consultations, drug prescriptions, admission to hospital, and death.

Subjects were seen at home as soon as possible after onset of illness. Diagnostic specimens were collected as described previously,[3] and symptoms were converted into syndromes.[3 4] The illness was considered lower

respiratory if productive cough, wheezy breathing, or pain on respiration were present, irrespective of other respiratory symptoms. It was considered to be an upper respiratory tract infection if coryza was present without lower respiratory symptoms. If sore throat or hoarseness was present without any of the above symptoms the illness was identified as laryngopharyngeal. Illnesses without any of the above symptoms but with only non-productive cough, earache, nasal stuffiness, or other symptoms were classified as other.

We studied 533 volunteers, 441 during the first winter and 439 during the second.[3] The 257 men and 276 women were aged 63-90 (mean (SD) 72.6 (5.7)) years and 60-90 (71.8 (6.1)) years, respectively, on recruitment. More men than women (207 (81%) *v* 129 (47%), χ^2 test $P < 0.001$) were either current or past smokers, but men and women were comparable with respect to indications for influenza vaccine[5]; vaccine uptake; admission to hospital during the preceding 5 years; attendance at a hospital outpatient department during the preceding 12 months; and proportions consulting their medical practitioner during the preceding 12 months. The project was approved by the Leicestershire ethics committee and signed informed consent was obtained from all volunteers.

Virology

Nasal swabs were placed high in the anterior nares and throat swabs were passed firmly over the tonsils and pharynx. Swabs were immediately placed in medium containing nutrient broth, transported on dry ice, and stored at −70°C. Serum samples taken during the acute and convalescent phase were stored at −20°C and tested later by complement fixation tests for antibodies to adenovirus; influenza A and B; respiratory syncytial virus; parainfluenza viruses types 1, 2, and 3; *Mycoplasma pneumoniae*; and *Chlamydia psittaci*. Haemagglutination inhibition tests were also carried out for the identification of infections by influenza type A. A fourfold rise in antibody titre was taken as indicating infection. Enzyme linked immunosorbent assay was used to detect rises in antibodies to coronaviruses 229E and OC43.[6] Rhinoviruses in nose and throat swabs were identified with a seminested reverse transcriptase polymerase chain reaction.[6 7] Rhinovirus serotypes 14 and 1B were used as positive controls; additional controls included baseline samples, water, and transport medium. The appearance of a 202 base pair amplification was taken to indicate rhinovirus infection.

Estimates of disease burden

We compared the disease burden of episodes for which diagnostic specimens were provided with the method used by the US Institute of Medicine's committee on issues and priorities for new vaccine development for diseases of importance in the United States.[8] The remit of the committee was to develop a comprehensive approach to setting priorities for accelerated vaccine development. In the decision making framework information on morbidity and mortality are combined into a single numerical score, which permits quantitive comparison of the burdens of morbidity and mortality rising from different pathogens. Given that individual pathogens may cause a spectrum of acute and chronic illness the committee estimated the number of cases of different infections occurring in different morbidity categories, namely: A—causing moderate localised pain, mild systemic reaction, or impairment requiring minor change in normal activities; B—causing moderate pain or moderate impairment requiring moderate change in normal activities (for example, housebound or in bed); C—requiring admission to hospital; D and E—relating to chronic disability; F—relating to total impairment; G—relating to reproductive impairment resulting in infertility; and H—relating to death. The unit of comparison between categories was designated as the "infant mortality equivalent."

In the present study illnesses not affecting the lower respiratory tract or not causing impairment resulting in a change in normal activities (confinement to bed or inability to cope with household activities) were categorised "low morbidity" (category A). Episodes affecting the lower respiratory tract or confining subjects to bed or affecting their ability to cope with shopping, cooking, or washing were considered "moderate" (category B); those resulting in admission to hospital were category C, and deaths were category H. Episodes with identification of more than one pathogen and pathogens causing fewer than 10 episodes were excluded from the comparative analysis. Disease burden values for categories A, B, and C were calculated from the product of the number of cases and the median duration of illness for that category divided by infant mortality equivalence values for each category: 2 000 000 for category A, 100 000 for category B, and 80 000 for category C.[8] The disease burden from category H was calculated from the number of deaths divided by an infant mortality equivalence value of 3.[8] These values represent a median of the perspectives of original committee members. The total score for each pathogen is the sum of category subtotals.

Statistics

Baseline variables in men and women and people with coronavirus, rhinovirus, influenza, and respiratory syncytial virus infections and episodes caused by unknown agents were compared by χ^2 tests for discrete variables and Kruskall-Wallis tests for continuous variables. Differences in the distributions of variables between different infections were assessed by χ^2 tests for discrete variables and Kruskall-Wallis tests for continuous variables. The Mann-Whitney U test was used to compare the intervals between onset of illness and medical consultation for people with influenza and other infections and duration of illness in those with and without lower respiratory illness.

Results

Clinical episodes

Volunteers completed 24 700 patient weeks of observation. We identified 706 episodes, occurring at a median rate of 1.2 episodes per person per annum (95% confidence interval 1.0 to 1.7; range 0-10) in 384 (72%) subjects. Symptoms were documented for 691 episodes. Laboratory specimens were collected a median of four days after onset of symptoms (range 1-21 days) for 497 (72%) of the 691 classified episodes. Missing specimens occurred when there were delays in reporting illness—notably, during Christmas, New Year, and Easter and periods of travel.

Table 1 Pathogens identified during 211 of the 497 upper respiratory episodes for which laboratory specimens were available

Pathogen	Single infections	Coinfections	Total
Rhinovirus	107	14	121
Coronaviruses	45	14	59
Influenza A and B	19	3	22
Respiratory syncytial virus	11	6	17
Parainfluenza	6	1	7
Chlamydia spp	3	0	3
Mycoplasma pneumoniae	1	0	1
Adenovirus	1	0	1
Total	193	38	231

Laboratory findings

Infection with 231 pathogens was identified for 211 (43%) of the 497 episodes (table 1). Of the 231, 121 were rhinoviruses (52%), 59 (26%) were coronaviruses, 22 were influenza A or B (9.5%), 17 were respiratory syncytial viruses (7%), 7 (3%) were parainfluenza viruses, and 3 (1%) were *Chlamydia*; an adenovirus and *Mycoplasma pneumoniae* caused one infection each.

Characteristics of respiratory viral illness

To avoid over-representation of symptoms of subjects with more than one infection, we focused on infections in different subjects. Table 2 shows the manifestations of 291 single infections occurring in 291 people with rhinovirus, coronavirus, influenza A and B, or respiratory syncytial virus infection and infections of unknown aetiology; and demographic features associated with episodes. Coinfections and infections due to parainfluenza viruses, adenoviruses, *Mycoplasma pneumoniae*, and *Chlamydia* species are excluded because of their small number. Most subjects (284; 98%) had upper respiratory symptoms; 189 (65%) had lower respiratory syndromes, and more than half (170; 58%) had systemic features. Table 2 shows that age, sex, and current smoking status of the groups were comparable; though the prevalence of chronic medical conditions that are indications for influenza vaccine differed among the groups (χ^2 11.09; 4df; $P < 0.05$).

There were no pathognomonic features for any pathogen (table 2). The median duration of the 291

Table 2 Demography and clinical characteristics of 291 acute upper respiratory tract infections in 291 elderly people.Values are numbers of patients (percentages; 95% confidence intervals) unless stated otherwise

Feature	Coronavirus (n=42)	Influenza (n=19)	Rhinovirus (n=85)	Respiratory syncytial virus (n=11)	Unknown (n=134)	P value
Demography						
No (%) of men	15 (36)	10 (53)	33 (39)	7 (64)	67 (50)	NS
Median (range) age (years)	70.5 (60-87)	70 (65-89)	72 (61-88)	70 (62-86)	71 (61-86)	NS
Current smoker	3 (7; 0 to 15)	6 (32; 11 to 53)	11 (13; 6 to 20)	1 (9; 0 to 26)	21 (16; 10 to 22)	NS
Indication for influenza vaccine	25 (60; 45 to 75)	4 (21; 3 to 39)	50 (59; 49 to 70)	4 (36; 8 to 64)	67 (50; 42 to 59)	<0.05
Symptoms						
Upper respiratory:						
Rhinorrhoea	30 (71; 57 to 85)	12 (63; 41 to 85)	61 (72; 63 to 82)	9 (82; 59 to 100)	95 (71; 63 to 79)	NS
Sneezing	25 (60; 45 to 75)	6 (32; 11 to 53)	59 (69; 59 to 79)	9 (82; 59 to 100)	81 (60; 52 to 68)	<0.05
Sore throat	24 (57; 42 to 72)	11 (58; 36 to 80)	55 (65; 55 to 75)	9 (82; 59 to 100)	71 (53; 45 to 62)	NS
Dry cough	19 (45; 30 to 60)	10 (53; 31 to 75)	39 (46; 35 to 57)	3 (27; 1 to 53)	60 (45; 37 to 53)	NS
Nasal congestion	22 (52; 37 to 67)	9 (47; 25 to 69)	39 (46; 35 to 57)	8 (73; 47 to 99)	59 (44; 36 to 52)	NS
Hoarseness	19 (45; 30 to 60)	5 (26; 6 to 46)	35 (41; 31 to 52)	3 (27; 1 to 53)	53 (40; 32 to 48)	NS
Purulent nasal discharge	12 (29; 15 to 43)	6 (32; 11 to 53)	26 (31; 21 to 41)	6 (55; 26 to 84)	33 (25; 18 to 32)	NS
Any upper respiratory symptom	41 (98; 94 to 100)	19 (100)	83 (98; 95 to 100)	11 (100)	130 (97; 94 to 100)	NS
Lower respiratory:						
Purulent sputum	16 (38; 23 to 53)	13 (68; 47 to 89)	49 (58; 48 to 69)	8 (73; 47 to 99)	92 (69; 61 to 77)	<0.01
Wheeze	9 (21; 9 to 33)	8 (42; 20 to 64)	25 (29; 19 to 39)	7 (64; 36 to 92)	45 (34; 26 to 42)	NS
Pain on respiration	3 (7; 0 to 15)	3 (16; 0 to 32)	12 (14; 7 to 21)	0	11 (8; 3 to 13)	NS
Any lower respiratory symptom	18 (43; 28 to 58)	15 (79; 61 to 97)	54 (64; 54 to 74)	9 (82; 59 to 100)	93 (69; 61 to 77)	<0.02
Systemic:						
Headache	20 (48; 33 to 63)	13 (68; 47 to 89)	34 (40; 30 to 50)	6 (54; 25 to 84)	51 (38; 30 to 46)	NS
Feverishness	8 (19; 7 to 31)	9 (47; 25 to 69)	20 (24; 15 to 33)	3 (27; 1 to 53)	28 (21; 14 to 28)	NS
Sweating	4 (10; 1 to 19)	9 (47; 25 to 69)	14 (16; 8 to 24)	3 (27; 1 to 53)	24 (18; 12 to 25)	<0.01
Myalgia	10 (24; 11 to 37)	9 (47; 25 to 69)	11 (13; 6 to 20)	3 (27; 1 to 53)	29 (22; 15 to 29)	<0.05
Rigors	0	3 (16; 0 to 32)	2 (2; 0 to 5)	0	4 (3; 0 to 6)	<0.02
Any systemic symptom	26 (62; 47 to 77)	16 (84; 68 to 100)	48 (56; 45 to 67)	8 (73; 47 to 99)	72 (54; 46 to 62)	NS
Other:						
Lacrimation	9 (21; 9 to 33)	1 (5; 0 to 15)	25 (29; 19 to 39)	4 (36; 8 to 64)	35 (26; 19 to 33)	NS
Painful cervical adenopathy	3 (7; 0 to 15)	1 (5; 0 to 15)	8 (9; 3 to 15)	1 (9; 0 to 26)	16 (12; 7 to 18)	NS
Faceache	3 (7; 0 to 15)	2 (10; 0 to 23)	10 (12; 5 to 19)	2 (18; 0 to 41)	11 (8; 3 to 13)	NS
Earache	5 (12; 2 to 22)	1 (5; 0 to 15)	7 (8; 2 to 14)	4 (36; 1 to 64)	12 (9; 4 to 14)	<0.05
Gritty eyes	3 (7; 0 to 15)	1 (5; 0 to 15)	8 (9; 3 to 15)	0	13 (10; 5 to 15)	NS
Any other symptom	15 (37; 22 to 52)	5 (26; 6 to 46)	37 (44; 33 to 55)	5 (45; 16 to 74)	61 (46; 38 to 54)	NS
Impact						
Confined to bed	10 (24; 11 to 37)	12 (63; 41 to 85)	24 (16; 8 to 24)	4 (36; 8 to 64)	32 (24; 17 to 31)	<0.001
Unable to cope with washing, shopping or cooking	15 (36; 21 to 51)	14 (74; 54 to 94)	21 (25; 16 to 34)	5 (45; 16 to 74)	46 (34; 26 to 42)	<0.01
Domiciliary consultation	3 (7; 0 to 15)	5 (26; 6 to 46)	6 (7; 2 to 12)	3 (27; 1 to 53)	12 (9; 4 to 14)	<0.05
GP consultation	11 (26; 13 to 39)	9 (47; 25 to 69)	37 (44; 33 to 55)	5 (45; 16 to 74)	55 (41; 33 to 49)	NS
Antibiotics	10 (24; 11 to 37)	9 (47; 25 to 69)	29 (34; 24 to 44)	4 (36; 8 to 64)	48 (36; 28 to 44)	NS

NS = not significant (P>0.05).

episodes was 15 days (range 2-79). It was longer in those with lower respiratory symptoms (median duration 16 days *v* 12 days (Mann-Whitney test, $P<0.0001$)), which occurred in 18/42 (43%; 95% confidence interval 28% to 58%) coronavirus infections, 54/85 (64%; 54% to 74%) rhinovirus infections, 93/134 (69%; 61% to 77%) unknown infections, 15/19 (79%; 61% to 97%) influenza infections, and 9/11 (82%; 59% to 100%) respiratory syncytial virus infections (χ^2 13.26; 4df; $P<0.02$) (table 2). The incidence of sweats, myalgia, rigors, earache, confinement to bed, capacity to carry out shopping, cooking or washing, and domiciliary medical consultations also differed when infections in table 2 were compared. Patients with influenza had high rates of myalgia, sweats, and rigors; 63% (12/19) were confined to bed, almost three quarters were unable to carry out shopping, cooking, or washing, and lower respiratory symptoms were common (15/19; 79%). Similarly most (9/11; 82%) of those with respiratory syncytial virus had lower respiratory symptoms.

During the influenza A epidemic in 1993-4, 41% (7/17) of patients with influenza confirmed by laboratory tests had myalgia with one or more respiratory symptoms (sensitivity), and the percentage of all episodes during the epidemic with myalgia and respiratory symptoms that were confirmed as influenza A (the positive predictive value) was 28% (7/25). The sensitivity was 29% (5/17) with the symptom complex of myalgia, respiratory symptoms, and feverishness or sweats, and the positive predictive value was 33% (5/15). The sensitivities remained identical during non-epidemic periods, but the positive predictive values fell to 7% (7/99) and 9% (5/58), respectively, with the above symptoms.

General practitioner review

Overall 117 (40%) of the 291 episodes were reviewed medically and 100 (34%) were treated with antibiotics. Consultation rates were higher for lower respiratory episodes than the remainder (96/189 (51%) *v* 21/102 (21%); χ^2 25.14; $P<0.001$). Comparison of the different infections revealed a difference in domiciliary consultation rates (χ^2 10.07; 4df; $P<0.05$), though neither the combined practice and domiciliary consultation rates nor the rates of antibiotic prescription differed (table 2). Of 19 people with influenza A as sole pathogen, nine were reviewed by a medical practitioner a median of 3 days after onset of symptoms (range 1-14). Similarly, 108/272 (40%) coronavirus, rhinovirus, respiratory syncytial virus and unidentified infections were reviewed after a median of 5 days (range 1-29 days) (Mann-Whitney U test, $z=0.538$; $P=0.59$) (table 2).

Deaths and admissions to hospital

Altogether three of the 497 infections led to admission to hospital and another was fatal. One woman died from chronic obstructive airways disease exacerbated by a rhinovirus. A second woman with chronic airways disease developed wheeze with sputum production and was in hospital for 6 days with influenza A. Two patients with chronic respiratory disease were admitted for 12 days and 4 weeks with exacerbations after upper respiratory infections of unknown aetiology.

Table 3 Total disease burden values and ranking according to pathogen responsible

Detail	Rhinovirus	Unknown	Coronavirus	Influenza	Respiratory syncytial virus
No of cases in category A/total	31/107	72/286	12/45	1/19	2/11
Total disease burden value	0.34773	0.03428	0.00467	0.00352	0.00200
Ranking	1	2	3	4	5

Disease burden values

Table 3 shows the disease burden values and the proportion of cases in category A. Influenza had the smallest proportion of cases with low morbidity (category A), but it ranked fourth overall after rhinovirus infections, episodes of unknown aetiology, and coronavirus infections.

Discussion

Our subjects suffered a median of 1.2 acute "upper" respiratory tract infections per annum, which is virtually identical with rates reported for frail elderly people attending day care units[9] and people aged 60 years and over living in the community in Tecumseh.[10] In contrast with the results of Falsey et al, who found respiratory syncytial virus to be the most common cause of acute respiratory illness in elderly people attending day care units,[9] we used the polymerase chain reaction instead of viral cultures to identify rhinoviruses and an enzyme immunoassay to identify infections with coronavirus OC43. We used a less sensitive technique to identify respiratory syncytial virus, but the same techniques to identify infections with influenza A and B and coronavirus 229E.

Although we invited a randomly selected population of elderly people in Leicestershire to take part in the study, participants may have been more health conscious than non-participants and report symptoms and consult their general practitioner for minor respiratory complaints more readily, thus introducing bias. Indeed, comparatively few were current smokers, and the overall immunisation rate in relation to the prevalence of chronic medical conditions was high.[3] The timing of the study could also introduce bias as there may have been unusually low attack rates for influenza in elderly people during 1992-3 and 1993-4 or variants of influenza causing little morbidity. Similarly failure to obtain diagnostic specimens due to delays in reporting illness could introduce bias relating to seasonal infections.

Scope for antiviral treatment

As in other studies of colds we found rhinoviruses followed by coronaviruses to be the most common pathogens,[6 10-12] and as in children,[13 14] healthy adults,[15 16] and frail elderly people[9 10 17] we identified no pathognomonic features for any pathogen. As amantadine and rimantadine are effective when given within 24 to 48 hours after onset of influenza A[18-21] we evaluated the sensitivity and positive predictive value of influenzal symptoms. One or more respiratory symptoms and myalgia occurred in only 41% of patients with influenza, and only 28% of episodes with these features were confirmed as influenza. The inclusion of feverishness or sweats as diagnostic criteria reduced the sensitivity to 29% and increased the positive predictive value to 33%. Temperature was not measured in our study, but raised

Key messages

- There are few data on the morbidity associated with respiratory viruses other than influenza in elderly people
- Respiratory virus infections in elderly people are clinically indistinguishable, and patients with influenza will be difficult to target for antiviral treatment without a near patient diagnostic test
- Overall, two thirds of elderly people with colds and four fifths of those with influenza and respiratory syncytial virus can be expected to develop lower respiratory illness
- Although influenza and respiratory syncytial virus cause substantial morbidity in elderly people, the disease burden from rhinovirus infections and colds of unknown aetiology is greater overall
- Most elderly patients seek medical attention beyond 48 hours when the benefits of antiviral treatment of influenza remain unproved

temperature occurs in similar proportions of influenza, respiratory syncytial virus, rhinovirus, and coronavirus infections in elderly people.[9 17] We conclude that patients with influenza will be difficult to target for antiviral chemotherapy without a rapid, near-patient diagnostic test. Moreover patients with influenza A in our study consulted their practitioner a median of 3 days after onset, suggesting that many elderly people with influenza may seek medical attention too late for successful treatment.

Burden of illness

To compare burden of illness caused by respiratory viruses we used a method developed to set priorities for accelerated vaccine development. The method was originally applied by using estimates of disease incidence in the United States, but even with this and other difficulties the system has been a useful tool. In our study we applied the method to a small cohort, but disease incidence and morbidity were monitored closely over two winters.

An intriguing observation in this study is the high incidence of lower airways being affected during colds. Respiratory syncytial virus and influenza were often complicated by lower respiratory illness, and respiratory syncytial virus closely resembled influenza in terms of domiciliary medical consultations. Interestingly, Falsey et al noted similar clinical manifestations during 159 respiratory syncytial virus and 221 influenza illnesses among elderly people living in the community who were admitted to hospital with acute cardiopulmonary conditions; they observed mortality of 10% and 6% for respiratory syncytial virus and influenza, respectively, and concluded that respiratory syncytial virus causes serious disease in these older people.[22] The overall burden of respiratory syncytial virus in our study was lower than that for influenza but is probably underestimated because of the use of the complement fixation test to diagnose respiratory syncytial virus. None the less, our observations and those of other investigators[1 9 17 22] provide strong support for an assessment of candidate respiratory syncytial virus vaccines in elderly people.

Unlike respiratory syncytial virus and influenza, coronaviruses caused respiratory illness throughout the study. They were associated with lower respiratory illness in more than 40% of patients and a quarter consulted a medical practitioner and received antibiotics. Coronaviruses represent the second most common cause of colds in adults and, in our cohort, gave a higher disease burden value than influenza or respiratory syncytial virus.

In our first report we speculated whether the burden of rhinovirus infections in elderly people might approach that of influenza.[3] In this study we found that a greater burden came from rhinoviruses, pathogens that we were unable to identify, and coronaviruses. Mortality increases considerably during the winter months, when consultations for upper respiratory syndromes increase.[1 23] It is therefore highly plausible that considerable morbidity and mortality from regular seasonal infections with rhinoviruses, coronaviruses, and respiratory syncytial virus have been overshadowed by less regular, readily recognisable epidemics of influenza.

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Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women

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Abstract

Objective: To assess the effectiveness of a home exercise programme of strength and balance retraining exercises in reducing falls and injuries in elderly women.

Design: Randomised controlled trial of an individually tailored programme of physical therapy in the home (exercise group, n = 116) compared with the usual care and an equal number of social visits (control group, n = 117).

Setting: 17 general practices in Dunedin, New Zealand.

Subjects: Women aged 80 years and older living in the community and registered with a general practice in Dunedin.

Main outcome measures: Number of falls and injuries related to falls and time between falls during one year of follow up; changes in muscle strength and balance measures after six months.

Results: After one year there were 152 falls in the control group and 88 falls in the exercise group. The mean (SD) rate of falls was lower in the exercise than the control group (0.87 (1.29) *v* 1.34 (1.93) falls per year respectively; difference 0.47; 95% confidence interval 0.04 to 0.90). The relative hazard for the first four falls in the exercise group compared with the control group was 0.68 (0.52 to 0.90). The relative hazard for a first fall with injury in the exercise group compared with the control group was 0.61 (0.39 to 0.97). After six months, balance had improved in the exercise group (difference between groups in change in balance score 0.43 (0.21 to 0.65).

Conclusions: An individual programme of strength and balance retraining exercises improved physical function and was effective in reducing falls and injuries in women 80 years and older.

Prospective community studies have detailed risk factors for falls in elderly people and identified those old people who are likely to fall; they also provide the basis for preventive studies.[1-3] The risk factors most commonly identified, which are possibly those most amenable to interventions that can be carried out in primary care, are loss of muscle strength and flexibility, and impaired balance and reaction time.[4] However, some studies have shown that increased activity in very old people can mean more falls and injuries.[5 6]

Meta-analysis of seven studies in the "frailty and injuries: cooperative studies of intervention techniques" trials showed that strength and balance training reduced the frequency of falls.[7] Three of the study sites showed an increased, but not statistically significant, risk of falling with the training programme. These studies used a variety of additional intervention strategies, and not all could be applied easily in a general practice setting.

A public health programme to reduce falls in elderly people needs to be simple, easy to implement, and affordable as well as effective. We developed a home based exercise and balance training programme which could be used in general practice. Age and female sex, the two most easily observable risk factors, were used to identify the study population.[4] We report the effect of a randomised, single blind controlled trial of a home based strength and balance retraining programme on the frequency of falls, injury from falls, balance, and muscle strength in women aged 80 years and older.

Methods

Study participants

Women aged 80 years and older living in the community were identified from the computerised registers of 17 general practices. They were invited by their general practitioner to take part in the study if they were able to move around within their own home and were not receiving physiotherapy.

Study design

Potential study subjects were visited at home by the research nurse. She obtained informed consent, filled in the mental status questionnaire in order to exclude those women unable to comply with the study requirements (score of <7 from 10), completed baseline questionnaires, and took a note of current medication.[8] Subjects subsequently visited a clinic for a baseline assessment and were then randomised to the control group or to receive the exercise programme. Six months later the physical assessments were repeated at the clinic by the same physiotherapist. The same research nurse completed the questionnaires at the subject's home after one year. Falls, injuries from falls, and compliance with the exercise programme were monitored for one year.

Monitoring falls and injuries

Falls were the main outcome measure and were defined as "unintentionally coming to rest on the ground, floor, or other lower level." Coming to rest against furniture or a wall was not counted as a fall.[9] Each subject was given a calendar comprising 12 addressed, reply paid postcards on which she could record falls daily for each month. Postcards were mailed back at the end of each month throughout the year, and the participant was contacted by telephone if the postcard was not returned. When a subject reported a fall, she was telephoned by the research team and the date and circumstances of the fall and

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Assessment tests to estimate balance, gait, strength, and endurance

- A functional reach test[13]
- Standing with feet side by side, standing with one foot next to and halfway in front of the other, standing with one foot directly behind the other, and standing on one foot with the other raised for up to 10 seconds,[14] scored as the 4-test balance scale[8]
- Strength of the knee extensor muscle on the subject's dominant side, tested with an electronic dynamometer[2]
- "Chair stand" test (time taken to rise from a chair and return to the seated position five times)[14]
- Time taken to walk eight feet[14] and 20 metres
- Time taken to climb up and down a set of four steps in the assessment room
- Distance walked in six minutes using the walking aid normally used outside the home[15]

details of any injuries were recorded on a fall event form. Injuries were defined as "serious" if the fall resulted in a fracture or admission to hospital or if any wounds needed stitches and "moderate" if there was bruising, sprains, cuts, abrasions, or a reduction in physical function for at least three days, or if the woman sought medical help. The circumstances of "serious" injuries were confirmed from hospital records. An investigator (AJC) who did not know to which group individual women belonged reviewed all fall events to determine if they met the fall definition and to classify the injury. Falls and injuries were monitored until the date of death or withdrawal from the study.

Health measures

At entry to the study, a medical history was taken; demographic information and details of social support, current medication, and health related behaviours were recorded; and weight, height, visual acuity, blood pressure while sitting and standing, and heart rate were measured. The instrumental activities of daily living scale, physical self maintenance scale, fear of falling, and the physical activity scale for the elderly questionnaires were completed at entry to the study and after one year.[10-12]

Physical assessment

Physical assessment measures were chosen to evaluate balance, gait, strength, and endurance. The same tests were repeated at entry to the study and after six months. The assessments are shown in the box.

Programme

The physiotherapist visited each subject who had been randomised to the exercise group four times over her first two months in the study. She prescribed a selection of exercises from the programme at appropriate and increasing levels of difficulty, and a walking plan. Each home visit took approximately one hour. Exercises included moderate intensity strengthening exercises with ankle cuff weights (0.5 kg and 1 kg) for the following muscle groups: hip extensor and abductor muscles, knee flexor and extensor muscles, inner range quadriceps, and ankle plantar and dorsiflexor muscles. Other exercises were standing with one foot directly in front of the other; walking placing one foot directly in front of the other; walking on the toes and walking on the heels; walking backwards, sideways, and turning around; stepping over an object; bending and picking up an object; stair climbing in the home; rising from a sitting position to a standing one; knee squat; and "active range of movement" exercises (for example, neck rotations and hip and knee extensions).

The exercises took about 30 minutes to complete. The women following the exercise programme were told to complete it at least three times a week and were encouraged to walk outside the home at least three times a week. Safety was ensured by prescribing each exercise appropriately, by giving the women adequate instructions on each exercise, and by providing an instruction booklet with illustrations. After the fourth visit, participants were encouraged to continue the exercise programme on their own and to telephone the physiotherapist with any problems. Subjects were telephoned regularly to maintain motivation.

Participants recorded whether they had completed the prescribed exercises or walked each day on a postcard calendar similar to the one used to record falls; they posted this back at the end of each month. The research nurse made a social visit to those in the control group four times during the first two months and telephoned them regularly during the year of follow up.

Statistical analysis

The sample size calculation was based on the proportion of elderly women who had fallen once or more during a 12 month prospective study in the community.[2] Numbers of women in the groups were based on the expectation that the exercise programme would reduce the proportion of women who fell during the year by 20% and allowed for a significance level of 0.05, a power of 0.80, and a drop out rate of 20%. Data were analysed on an intention to treat basis using SPSS version 6.1.1. Baseline characteristics and changes from baseline to six months and baseline to one year were compared in the two groups using the χ^2 test, Student's t test, or the Mann-Whitney U test as appropriate. The event rate was calculated as the mean of the number of falls divided by the time over which falls were monitored for each participant, and the 95% confidence interval of the difference was calculated assuming a negative binomial distribution.[16] Proportional hazards models were used to determine relative hazards for the two groups for a first fall and a first fall with injury. A relative hazard was calculated to compare the two groups using the Andersen-Gill extension of the Cox model, which allows for multiple events per subject (SAS version 6.1).[7] We used the first four falls for each participant in this analysis rather than all falls (maximum 10) to avoid overweighting by subjects who fell more than four times.

Ethical approval

All subjects gave informed consent. Approval for the study was given by the Southern Regional Health Authority's ethics committee (Otago).

Group assignment and blinding

The group allocation schedule was developed by a statistician using computer generated random numbers and the list was held off site by an independent

person. Group assignment was made by telephone contact after all baseline questionnaires and assessments were completed. The assessment physiotherapist and investigator classifying fall events remained blind to group allocation.

Results

The progress of the participants through the trial is shown in figure 1.

Analysis

Characteristics of women at entry to the study are given in table 1. Two measures differed between the groups, but these were not related to the risk of falling and did not influence the findings of the study.

After six months balance had improved in the exercise group compared with the control group (mean (SD) changes in the 4-test balance score were 0.42 (0.86) and −0.01 (0.80) respectively; difference 0.43; 95% confidence interval 0.21 to 0.65). A higher proportion of those in the exercise group had improved their performance in the chair stand test (relative risk 1.41; 1.07 to 1.87). There were no differences between the two groups for the remaining physical assessment measures.

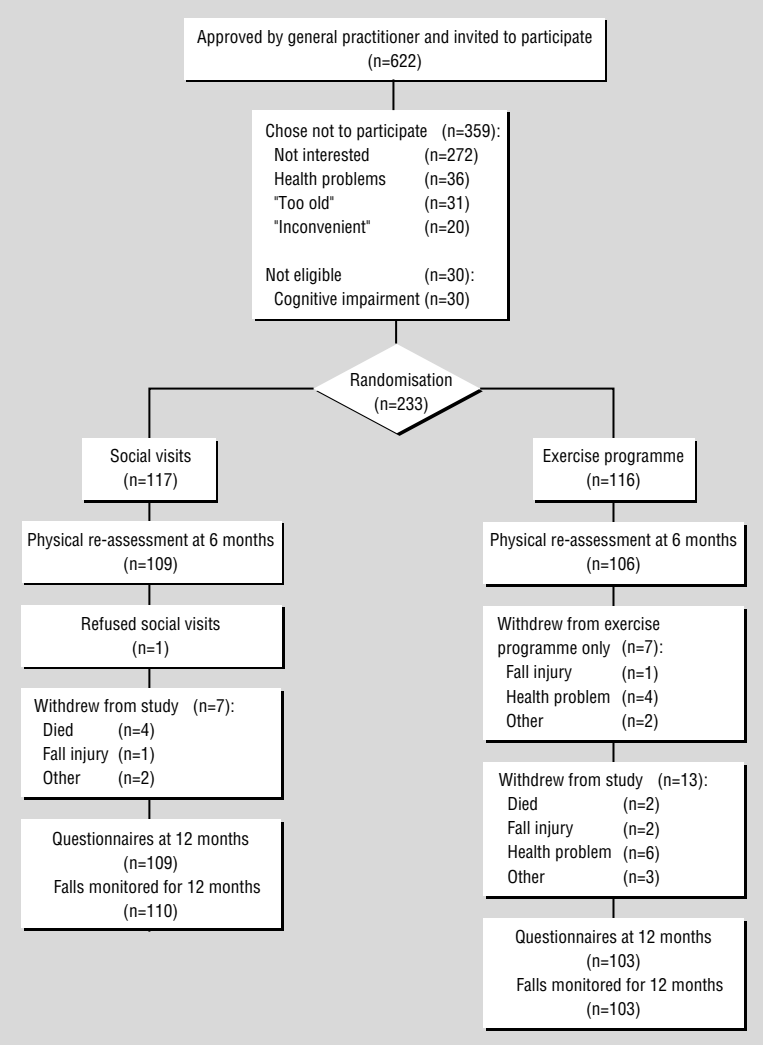
After one year of follow up there had been 152 falls in the control group and 88 falls in the exercise group. The total follow up time was 113.4 person years for the control group and 108.8 person years for the exercise group. The mean (SD) rate of falls per year was lower in the group receiving the exercise programme than in the control group (0.87 (1.29) and 1.34 (1.93) falls per year respectively; difference 0.47; 95% CI 0.04 to 0.90). The number of falls for study participants is shown in table 2.

The hazard ratio for a first fall in the exercise group compared with the control group was 0.81 (0.56 to 1.16). With the Andersen-Gill extension of the Cox model, the hazard ratio for the exercise group compared with the control group for the first four falls was 0.68 (0.52 to 0.90).

Elderly people who had four or more falls during follow up had a higher risk of having fallen in the previous year than the remainder of the participants (13 of 17 *v* 81 of 195: relative risk 1.84; 1.35 to 2.51), but values at baseline did not differ for any other variables.

Eighty five falls resulted in moderate injury and 25 in severe injury. The hazard ratio for a first fall with injury was 0.61 (0.39 to 0.97). The proportion of subjects monitored for the full 12 months (n = 213) who were injured from a fall was lower in the exercise group than in the control group (26.2% (27 of 103) *v* 39.1% (43 of 110); relative risk 0.67; 95% CI 0.45 to 1.00).

After one year 42% (48 of 114) of the survivors in the exercise group were still completing the programme three or more times a week. The control group became less active (mean (SD) change in the physical activity scale for the elderly score −11.0 (22.3) *v* −4.6 (22.9); difference 6.4; 0.2 to 12.6), and their fear of falling increased (mean (SD) change in falls self efficacy score −6.1 (12.2) *v* −2.5 (11.1); difference 3.6; 0.4 to 6.8). There were no differences between the group scores for the instrumental activities of daily living scale (median 8.0; range 0 to 8) or the physical self maintenance scale (6.0; 3 to 6) at baseline or after one year (7.0; 0 to 8 and 5.0; 2 to 6, respectively).



Flow chart showing numbers and timing of randomisation to control or exercise groups, interventions, and outcome measures

Table 1 Characteristics of subjects in control and exercise groups at entry to study. Values are numbers (percentages) unless indicated otherwise

Characteristic	Control group (n=117)	Exercise group (n=116)	Difference (95% CI)
Mean (SD) age (years)	84.1 (3.4)	84.1 (3.1)	NS
Mean (SD) score on physical activity scale for the elderly	53.8 (29.8)	49.2 (30.2)	NS
Mean (SD) score on falls efficacy scale	92.5 (10.0)	90.8 (10.6)	NS
Mean (SD) total No of medications	2.8 (2.3)	3.7 (2.7)	0.9 (0.3 to 1.5)*
Uses sedative drugs	22 (19)	25 (22)	NS
Postural hypotension	17 (15)	19 (16)	NS
Lives alone	89 (76)	90 (78)	NS
Fall in previous year	55 (47)	47 (41)	NS
Previous hip fracture	11 (9)	8 (7)	NS
Other previous fracture	46 (39)	48 (41)	NS
History of stroke	7 (6)	13 (11)	NS
History of knee arthritis	22 (19)	41 (35)	16.5 (5.3 to 27.7)*
Uses community services	21 (18)	26 (22)	NS

*Significantly different at baseline but not found to be related to the risk of falling.

Discussion

We have shown that a programme of strength and balance training exercises, which could be done at home and organised by general practices, reduced significantly the number of falls and injuries experienced

Table 2 Number (percentage) of subjects falling in control and exercise groups*

	Control group (n=117)	Exercise group (n=116)
No of falls:	152	88
0	55 (47)	63 (54)
1	28 (24)	31 (27)
2	16 (14)	14 (12)
3	3 (3)	6 (5)
⩾4	15 (13)	2 (2)

*Mean (SD) follow up was 11.6 (1.7) months for the control group and 11.3 (2.3) months for the exercise group.

by women aged 80 years and older. The reduction in the rate of falls was greater than that found in the combined frailty and injuries cooperative studies of intervention techniques studies, but similar to that achieved by combined interventions.[3 7]

Improvement in balance and strength

The exercise group showed improved balance and an improved performance in the chair stand test. Improvement in balance has been shown in previous studies, but has usually come about through group activities or by means of specific training equipment.[17-19] Community programmes have also shown improvements in balance and reaction time in elderly people, but no reduction in the frequency of falls.[20] The combined interventions of Tinetti and colleagues led to a significant improvement in balance and in transferring safely from one position to another.[21]

Prevention of falls

The balance retraining programme strengthened postural control mechanisms, but initially it put the elderly woman at risk of falling. Our strength retraining programme required an increase in activities such as daily walks and therefore increased the opportunities for falling. The time to first fall was used to assess this possible increase in the risk of early falls and was similar for the two groups.

Those who have one fall are more likely to have another.[1 2] This differing tendency for recurrence was allowed for in the rigorous analysis used.[16] One of the main differences between the two groups was in the prevention of several falls. At the Atlanta site of the "frailty and injuries: cooperative studies of intervention techniques," Tai Chi had most benefit in preventing several falls.[17] Although it could be argued that the programme should be directed at people who fall often, most older women are sufficiently susceptible to the risk of falling and sufficiently inactive to benefit from planned activity.[22] It is difficult to predict those who may start to fall frequently. In our study a history of previous falls was the only factor which could have been used to predict which subjects were likely to have frequent falls.

Key messages

- Modifiable risk factors for falls in elderly people have been well defined; they include loss of muscle strength and impaired balance
- A programme to improve strength and balance in women aged 80 years and older can be set up safely with four home visits from a physiotherapist
- This programme reduced falls and moderate injuries appreciably over the subsequent year in Dunedin, New Zealand
- The benefit was most noticeable in elderly people who fell often

Use of programme in general practice

The programme was designed to be used as part of a preventive plan based in general practice, but issues remain which need to be considered in the transition from a research project to a public health programme. The enthusiasm and commitment of the research physiotherapist may encourage greater compliance in the elderly people than is possible in the busy routine of a working practice. On the other hand, recruitment may improve when the programme is sponsored by the general practice. Our involvement was kept to a minimum but more regular encouragement during normal practice attendances may improve participation.

Although only 37% (233 of 622) of those aged 80 years and older on general practice lists participated in the programme, we did not have an elite, fit sample. Some of the women were very frail—the mean score on the physical activity scale for the elderly was only 51.5 within a possible range of 0 to 400. The high frequency of other risk factors for falls and the high fall rate overall in the study, similar to that observed in previous prospective studies,[1 2] also indicated that this was not an unusually sprightly group. Although there was some improvement in physical activity in the exercise group, the improvement was small and the nurse who completed the 12 month questionnaire was aware of group allocation. The improvements must therefore be interpreted with caution.

Results from a study such as this depend on the completeness of the reports of falls. Tear-off calendars have been used successfully before, and 88% of falls were notified in this way. If a calendar postcard was not returned, or if a fall was noted, the participant was contacted by telephone and details of the fall recorded on a structured event form.

Falls remain a major public health problem and affect the lives of many older people. Not only may an individual programme of physical activity reduce the risk of falls, it may improve health in other ways.[23 24] Younger people who have several falls may also benefit from the programme. Our study has shown that preventing falls through a home based programme in which strength and balance training is a key component can reduce the frequency of falls. The next step is to make the transition from trials of efficacy to trials of more general implementation and health promotion.

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Effectiveness of influenza vaccination policy at targeting patients at high risk of complications during winter 1994-5: cross sectional survey

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Each year the chief medical officer writes to general practitioners and other health professionals reminding them of the need to identify and vaccinate patients at risk of the complications of influenza—that is people who have chronic heart, chest, or kidney disease; people who have diabetes; people who are immunocompromised owing to treatment or disease; and people living in residential accommodation. Routine immunisation of elderly people is not recommended. Current data on the efficacy of influenza vaccine indicates that up to 70% of clinical cases could be prevented,[1 2] an important finding as in 1989, 26 000 people, mostly elderly, or those recommended for vaccination, died in the United Kingdom from influenza and its complications.[3] That year there was a good antigenic match between the epidemic strain and the one used in the vaccine, yet only one third to one half of all patients who would have benefited from vaccination received it.[4] I investigated the implementation of current vaccine policy.

Subjects, methods, and results

In September 1994, 64 general practices in the county of Gwent, with a registered population of 291 908, took part in a study that entailed data collection from patients at the time of vaccination. Patients were asked their age, whether they suffered with any of the conditions for which influenza vaccination is recommended, and the method by which they came to receive vaccination. A numerical coding system was used to separate out each chronic disease and the method used to contact patients. Only practices that were computer linked to the health authority patient register were used, and this provided patient denominator data. Practices for which the authority held denominator data on chronic diseases were used to calculate uptake rates of vaccine in at risk groups. Statistical analysis was carried out with SPSS 6.0 for Windows.

For the 28 433 doses of vaccine given in the 64 practices, information was submitted on 21 001 patients (74%). Overall, the vaccine uptake rate was 97.4 doses/1000 patients (table), though individual practices showed wide variation (range 25/1000 to 275/1000). Uptake rates in specific at risk groups were calculated for the practices that had recorded all of their immunisations. Analysis showed that under half of those patients identified as high risk and recommended for vaccination received it: only 63% of patients with heart disease, 39% with diabetes, 41% with asthma, and only one in three of those over 75. One quarter of all doses were given to patients at low risk. The table shows that advice from general practitioners accounted for 40% of all those being

Doses of influenza vaccine given to patients at high and low risk, showing relation with methods by which patients were contacted. Numbers in parentheses are percentages of total doses arising from that method of contact, unless stated otherwise

Contact method	Patients of all ages at high risk	Well patients <65 years at low risk	Well patients ≥65 years at low risk	Patients with other conditions not recommended for vaccination	Total doses given (% of total doses given to study population)
Advice from general practitioner	5495 (64)	480 (5.6)	1737 (20.2)	869 (10.1)	8581 (40.9)
Repeat prescription	263 (35.9)	73 (10)	332 (45.3)	64 (8.7)	732 (3.5)
Practice clinic	59 (86.7)	0	5 (7.4)	4 (5.9)	68 (0.3)
Hospital consultant	42 (84)	1	1	6 (12)	50 (0.2)
Practice nurse	1809 (58.5)	232 (7.5)	563 (18.2)	486 (15.7)	3090 (14.8)
Health visitor	48 (46.2)	4 (3.8)	50 (48)	2	104 (0.5)
District nurse	83 (53.5)	7 (4.5)	43 (27.7)	22 (14.2)	155 (0.7)
Postal reminder	77 (70.6)	3	28 (25.7)	1	109 (0.5)
Telephone reminder	54 (66.6)	9 (11.1)	8 (9.8)	10 (12.3)	81 (0.4)
Poster in surgery	243 (38.6)	153 (24.3)	72 (11.4)	161 (25.6)	629 (3)
Awareness due to media	66 (34.5)	63 (33)	27 (14.1)	35 (18.3)	191 (0.9)
Receives vaccine each year	2168 (40.9)	1079 (20.3)	1445 (27.2)	608 (11.5)	5300 (25.2)
Other methods	476 (24.9)	691 (36)	408 (21.3)	336 (17.5)	1911 (9)
Total (% of total doses given to study population)	10883 (51.8)	2795 (13.3)	4719 (22.5)	2604 (12.4)	21001 (100)

vaccinated, most of the remainder resulting from self referral by patients on an annual basis or on advice from the practice nurse. Other health professionals, particularly hospital consultants, played an insignificant part in vaccine promotion. Under 4% of patients were recruited by proactive methods such as telephone, letter, or a message on repeat prescriptions; 80% were recruited opportunistically. Poster campaigns had little influence in targeting those who would most benefit. There was no significant difference in uptake rates between practices according to whether they were training practices or fundholders, had more than two partners, or occupied cost-rent premises. There was also no relation with list size, though those practices with the highest vaccination rates had the highest uptake in those who would most benefit.

Comment

The methods used in this study tend to overestimate the uptake of influenza vaccine in patients with heart and respiratory disease because of denominator deficiencies—for example, in calculating the uptake rate in patients with respiratory disease, the denominator population was calculated using the number of patients with known asthma and did not include other chest complaints, which would lead towards an overestimation. This study showed that personal advice from a general practitioner or practice nurse during the vaccination period was the greatest stimulus to vaccine uptake. There was little evidence of practices using vaccination registers to plan their vaccination programmes, and other health workers, though targeting risk groups correctly, did so too infrequently to make an impact.

Influenza is an important disease of major public health concern, with an effective vaccine. The United Kingdom currently spends over £30m on influenza vaccination (derived from the drug tariff cost per dose for six million doses of vaccine given in the winter of the study), yet this merely covers the cost of vaccine and fails to deal with organisational issues. I have shown that the present system, which relies on the idiosyncratic behaviour of individuals with minimal central guidance, no mechanisms to ensure effective targeting of vulnerable groups, and no link between renumeration and performance, results in less than half of those who require vaccination receiving it, while half is given to people at low risk. This approach falls short of delivering an evidence based public health policy aimed at reducing the impact of one of the world's major killer diseases, as shown during the winter of 1989-90.

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Endpiece

Scientific distinction hampers private practice?

I have heard him say, that after his Booke of the *Circulation of the Blood* came out, that he fell mightily in his Practize, and that 'twas beleeved by the vulgar that he was crack-brained; and all the physitians were against his Opinion, and envyed him; many wrote against him.

John Aubrey (1626-97), *Brief Lives,* on William Harvey (1578-1657)