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Citation: Henderson, C., Knapp, M., Fernandez, J-L., Beecham, J., Hirani, S. P., Beynon, M., Cartwright, M., Rixon, L., Doll, H., Bower, P., et al (2014). Cost-effectiveness of telecare for people with social care needs: the Whole Systems Demonstrator cluster randomised trial. Age and Ageing, 43(6), pp. 794-800. doi: 10.1093/ageing/afu067

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Link to published version: https://doi.org/10.1093/ageing/afu067

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Age and Ageing 2014; **43:** 794–800
doi: 10.1093/ageing/afu067
Published electronically 20 June 2014

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Cost-effectiveness of telecare for people with social care needs: the Whole Systems Demonstrator cluster randomised trial

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Abstract

Purpose of the study: to examine the costs and cost-effectiveness of 'second-generation' telecare, in addition to standard support and care that could include 'first-generation' forms of telecare, compared with standard support and care that could include 'first-generation' forms of telecare.
Design and methods: a pragmatic cluster-randomised controlled trial with nested economic evaluation. A total of 2,600 people with social care needs participated in a trial of community-based telecare in three English local authority areas. In the Whole Systems Demonstrator Telecare Questionnaire Study, 550 participants were randomised to intervention and 639 to control. Participants who were offered the telecare intervention received a package of equipment and monitoring services for 12 months, additional to their standard health and social care services. The control group received usual health and social care.
Primary outcome measure: incremental cost per quality-adjusted life year (QALY) gained. The analyses took a health and social care perspective.
Results: cost per additional QALY was £297,000. Cost-effectiveness acceptability curves indicated that the probability of cost-effectiveness at a willingness-to-pay of £30,000 per QALY gained was only 16%. Sensitivity analyses combining variations in equipment price and support cost parameters yielded a cost-effectiveness ratio of £161,000 per QALY.
Implications: while QALY gain in the intervention group was similar to that for controls, social and health services costs were higher. Second-generation telecare did not appear to be a cost-effective addition to usual care, assuming a commonly accepted willingness to pay for QALYs.
Trial registration number: ISRCTN 43002091.

Keywords: *telecare, economic evaluation, social care, older people*

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Introduction

In the face of macroeconomic difficulties, budgetary pressures [1] and rapid demographic change, [2] government and non-governmental bodies are searching for more cost-effective ways of supporting independent living. 'Telecare', a remote and passive monitoring technology intended to allow users to live safely and independently [3], may play an important role in this effort. Telecare has been advocated as a means to generate cost savings, and maintain or improve the quality of service for people with social care needs [4]. However, evidence on the impact of assistive technologies to support independent living, such as 'telecare' and telehealth, is sparse; data are especially limited on cost-effectiveness.

We examined whether 'second-generation' telecare [5] in addition to standard support and care that could include 'first-generation' forms of telecare is cost-effective compared with standard support and care that could include 'first-generation' forms of telecare, under the Whole Systems Demonstrator (WSD) programme [6].

Design and methods

The study design was a pragmatic cluster-randomised controlled trial, examining the effectiveness of telecare for individuals with social care needs, and also their carers [7], when delivered in the context of routine health and social care practice [8]. Telecare was introduced in three English local authorities (sites), covering four Primary Care Trusts chosen as exemplifying on-going engagement in 'whole-systems redesign' (Supplementary data are available in *Age and Ageing* online file 1).

Intervention participants received a second-generation telecare package in addition to their existing social and healthcare services (which could include 'first-generation' forms of telecare); control group participants continued to receive their existing social care and health services (which could include 'first-generation' forms of telecare) for 12 months, after which they were offered telecare, subject to reassessment.

Individuals eligible for the trial were invited to participate in a nested questionnaire study; those who agreed were contacted by interviewers who, after obtaining written consent, administered instruments to measure outcomes [7] and collect information needed to calculate care costs. Individuals assessed as having cognitive impairment preventing them from completing outcome measures on their own were ineligible for the questionnaire study, while remaining eligible for the parent trial [9].

Service use data were collected using the Client Services Receipt Inventory [10], administered by interview at baseline and by self-completion postal questionnaire at 4- and 12-month follow-up. Participants were asked to report service use in the 3 months prior to each assessment. At 12-month follow-up, participants not returning questionnaires were contacted to arrange an interview (52% of questionnaires returned were completed by interview). We focus here on costs and outcomes collected for the questionnaire study at 12-month compared with baseline (Supplementary data are available in *Age and Ageing* online file 2 for 4-month follow-up statistics).

Telecare intervention and equipment

Telecare was defined in the trial as the 'remote, automatic and passive monitoring of changes in an individual's condition or lifestyle (including emergencies) in order to manage the risks of independent living' [7]. Telecare equipment used in the trial can be mapped to four broad functions: monitoring functional status (e.g. pendant, chair occupancy sensors), home security (bogus caller buttons, property exit sensors) and home environment (heat sensors, flood detectors), and facilitating the telecare package through 'stand-alone' devices that do not send alerts to the monitoring centre (big button telephones, key safes) (Supplementary data are available in *Age and Ageing* online file 3). Telecare users received an equipment package including base unit and pendant/bracelet and at least one of 27 types of telecare device.

While telecare in all three sites consisted of a call centre-based monitoring service responding to alarms and sensors, service models nonetheless varied (Supplementary data are available in *Age and Ageing* online Box 3.1, file 3). The purpose of the trial was not to evaluate specific models of delivery or technology configurations, but to evaluate whether second-generation 'telecare' in any of its configurations nested within a broader system of care is cost-effective compared with usual care.

Service use and costs

To calculate health and social care costs in the 3-month periods prior to baseline and 12-month assessments, self-reported units of service were multiplied by the relevant unit costs. Most unit costs (in 2009–10 prices) were nationally applicable and taken from published sources [11, 12] (Supplementary data are available in *Age and Ageing* online, Table A4.1). Costs calculated for these 3-month periods were multiplied by 4 to estimate costs in the pre-baseline year and in the year of the intervention period for use in the cost-effectiveness analyses. We also calculated the cost of a package of telecare equipment and support (Supplementary data are available in *Age and Ageing* online, file 3). Analyses took a health and social services perspective: we included costs incurred by the National Health Service (NHS) or local authorities. Costs disregarded any user charges; however, only those equipment and adaptations costs falling to the NHS or local authorities were included (excluding privately purchased equipment).

Outcomes

The primary outcome was incremental cost per quality-adjusted life year (QALY). QALYs were constructed, calculating utility scores from the EQ-5D, using societal weights [13], and taking the 'area under the curve', with linear interpolation between baseline and 12-month assessment

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scores. Secondary outcomes were: perceived physical and mental health status, psychological well-being and state-trait anxiety (Supplementary data are available in *Age and Ageing* online, file 5).

Statistical analysis

We examined relationships between costs and consequences of telecare by calculating the incremental cost-effectiveness ratio (ICER) and net monetary benefit (NMB) of the intervention. The ICER represents the difference in mean costs between intervention and control groups (ΔC) divided by the difference in mean outcome scores (ΔE). The intervention is seen as cost-effective if the ICER is less than some maximum amount (λ) that the payer is willing to pay (WTP) for a gain in outcome, a decision rule that can be expressed as $\Delta C/\Delta E < \lambda$. It follows that for the intervention to be cost-effective, $\lambda \times \Delta E - \Delta C > 0$, or put another way, that the NMB (given by $\lambda \times \Delta E - \Delta C$) exceeds zero [14]. NMB represents the pecuniary value of extra gains in outcome associated with the intervention, for a given WTP (λ), net of the extra cost of the intervention [14]. We explored the probability that telecare is cost-effective over a series of values of λ, from £0 to £90,000, encompassing the range of £20,000 to £30,000 per QALY considered by National Institute for Health and Care Excellence (NICE) for recommending use of technologies in the NHS [15]. Results were used to plot cost-effectiveness acceptability curves (CEACs).

We fitted seemingly unrelated regression (SUR) models of costs and outcomes by maximum likelihood estimation, using the user-written mysureg command [16] in Stata 12 [17]. SUR is a system of equations, allowing any correlation between the error terms of the cost and outcome equations to be captured in the estimation [18]. Covariates used in these analyses were baseline costs, baseline utility [19], site, age, sex, ethnicity, index of multiple deprivation (IMD) 2007 quintiles [20], a one-person household indicator, a count of chronic conditions [21], dependency (baseline EQ5-D self-care domain score) and whether the participant had a 'personal/community alarm' at baseline. Cluster-robust standard errors were used in estimating regression coefficients (observations were clustered by general practice). The difference between groups identified by the coefficient on the intervention variable in each equation was used to calculate the ICER and the NMB.

Missing data

Imputation of costs missing at the cost category level and of outcome data at the scale level was carried out using the MCMC multiple imputation package in SPSS v.19 (SPSS, Inc., Chicago, IL, USA) (Supplementary data are available in *Age and Ageing* online, file 6).

Results

There were 2,600 participants in the trial (1,276 randomised to telecare and 1,324 to usual care), from 217 general practices: 1,189 participated in the questionnaire study (550 telecare and 639 usual care) [9]. Cost data were available at baseline for 1,182 participants and at 12-month follow-up for 757 participants (64% of the baseline sample) (381 telecare and 376 control, 69 and 59% of the baseline sample, respectively). At 12-month follow-up, outcomes data were available for 379 telecare and 384 control participants (69 versus 60% of the baseline sample, respectively). Both baseline and follow-up costs were available for 375 intervention and 378 control participants.

Demographic characteristics did not differ significantly between baseline and 12-month follow-up for the sample with 12-month data within either control or intervention groups (Supplementary data are available in *Age and Ageing* online, Table A7.1). However, participants not completing the follow-up were on average older than the baseline sample [75.9 (SD 14.0) versus 73.2 (SD 13.7) years, $t = 3.239$, $P = 0.0013$], with baseline costs £2,137 higher than completers [£10,874 (SD 14682) versus £8,738 (SD 10,652, $t = 2.9$, $P = 0.0004$)]. Participants in the usual care group with data available had significantly higher proportions in the 65–74 group and lower proportions in the 85+ group, lower proportions in site 2, higher proportions in site 3 and lower costs. Those with data available in the telecare group had higher proportions in the 65–74 group, and lower proportions in the 85+ group. Groups were well balanced at baseline and follow-up in terms of age, sex, mean IMD score and baseline costs, although at both points a larger proportion of the telecare group was in the second IMD quintile.

Service use and costs

Participants used many services in the 3 months prior to 12-month follow-up (Supplementary data are available in *Age and Ageing* online, Table A4.1). Differences (unadjusted for case mix) between groups were small for most categories. Reported use of such social services as home care and social work was greater in the telecare group. Control participants had 33 (SE 3.7) daytime home care visits on average over the period, while telecare participants had ~42 (SE 4.3) (difference of 9.6 contacts, standardised difference of 12%). Telecare participants reported more community nursing visits (difference of 1.6 visits, standardised difference 17%).

Proportions of participants having a 'personal/community alarm' (such as a community alarm or pull-cord) were well-balanced at baseline (51% control, 52% intervention group); however, at 12 months, the proportion reporting use of some form of community alarm in the control group was 64%, 26% higher in relative terms than at baseline (a difference in baseline and follow-up proportions of 13%, $z = -4.04$, $P = 0.0001$) (Supplementary data are available in *Age and Ageing* online, file 4, Table A4.2).

Participants received between 1 and 11 items of WSD telecare equipment (mean 4.7; mode 4) (Supplementary data are available in *Age and Ageing* online, file 3, Table A3.1). Average annuitised equipment costs were £81 (SE 1.9) for all participants completing baseline assessments and £82 (SE2.3) for those completing the 12-month follow-up (Table 1).

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Table 1. Mean service costs and QALY[a]

Resource item	Usual care (SE) (n = 378)	Telecare (SE) (n = 375)	Raw difference (95% CI)	Standardised difference (%)
Total hospital costs	1,861 (209.8)	2,042 (307.1)	181 (−548.5, 909.7)	3.5
Total primary care costs	926 (58.3)	1,075 (96.7)	149 (−72.2, 370.4)	9.6
Total care home respite costs	31 (20.6)	76 (44.6)	46 (−50.5, 141.8)	6.8
Total community care costs	2,850 (413.2)	3,324 (316.5)	474 (−548.7, 1,497)	6.6
Total mental healthcare costs	50 (25.3)	70 (43.7)	20 (−78.7, 119.2)	2.9
Total day care costs	757 (108.9)	787 (110.4)	30 (−274.6, 334.3)	1.4
Total adaptations costs	30 (8.3)	16 (3.4)	−15 (−32.3, 3.2)	−12.2
Total equipment costs	8 (1.8)	9 (2.2)	1 (−4.2, 6.9)	3.5
Total medication costs	778 (30.8)	718 (31.5)	−60 (−146.5, 26.4)	−9.8
Total costs excluding telecare delivery and equipment	7,290 (531.6)	8,117 (558.5)	826 (−687.1, 2,339.7)	7.8
Telecare equipment costs	4 (1)	82 (2.3)	78 (73, 82.9)*	149.4
Telecare intervention costs	35 (8.6)	710 (15.2)	676 (641.3, 709.9)*	163.0
Total costs including telecare delivery and equipment	7,329 (532.2)	8,909 (559.9)	1,580 (63.6, 3,096)**	14.9
Less project management posts and contracts	7,324 (532)	8,806 (559.6)	1,482 (2, 3,019.7)	13.9
Less dedicated responder costs	7,324 (532)	8,837 (560)	1,513 (32.9, 3,051)	14.2
Sensitivity				
At 50% reduction in equipment prices	7,298 (528.3)	8,862 (558.4)	1,564 (55.3, 3,072.4)*	14.7
£5 cost per week	7,306 (531.6)	8,450 (558)	1,144 (−332.5, 2,679.8)	10.8
£5 cost per week + 50% reduction in equipment prices	7,304 (531.6)	8,408 (558)	1,104 (−371.4, 2,640.7)	10.4
QALY	0.333 (0.016)	0.321(0.016)	−0.012 (−0.057, 0.034)	−3.7

[a]Annual equivalent costs for 753 cases with baseline cost data available.
*$P < 0.01$ on the t-test.
**$P < 0.05$ on the t-test.

Hospital costs constituted 25% of total health and social care costs at the 12-month follow-up (if excluding intervention costs); day care and community social care costs together contributed 50%, and primary care costs, 13% (Table 2). A telecare support and equipment package cost £791 per annum, contributing ∼9% to overall health and social care costs per person. Including direct intervention costs, intervention group costs (unadjusted for case-mix) were greater than control group costs (standardised difference 15%).

Cost-effectiveness

There was a small, not statistically significant difference in mean adjusted QALY scores at 12 months in favour of the telecare group [0.003 (−0.018, 0.024)] (Table 2). Costs, including intervention costs, were £1,014 (95% CI −525, 2,553) higher per annum for telecare than control participants. Cost per additional QALY was £297,000 (Table 2). ICERs for costs excluding project management and for costs excluding dedicated telecare responder costs were slightly lower (£269,000 and £277,000, respectively). The probability that a decision-maker would find telecare cost-effective at a willingness-to-pay of £30,000 for an additional QALY gain was 16% (Supplementary data are available in *Age and Ageing* online, Figure A8.1). The probability that telecare was cost-effective did not reach 50% even assuming willingness-to-pay of £90,000 per QALY. Excluding project management-specific posts and contracts, and assuming a willingness-to-pay of £30,000 per QALY, the probability that the intervention was cost-effective slightly increased to 18%. Analysis excluding the costs of dedicated response services in sites 2 and 3 yielded similar results. (see Supplement 5 for secondary outcome results.)

Sensitivity analyses

Assuming that telecare support might be delivered at a lower ('mainstream') cost of £5 per week [22], the probability of telecare being cost-effective at a WTP of £30,000 was 30%. The ICER was £173,000 (Table 2). Input prices for equipment were varied by assuming that equipment was purchased at half the price paid within the trial: the probability of telecare being cost-effective changed slightly to 17%, at WTP of £30,000 (Supplementary data are available in *Age and Ageing* online, Figure A8.2). Combining equipment and support cost scenarios, the probability that telecare was cost-effective was 31% at a WTP of £30,000, and the ICER was £161,000.

Discussion

This large-scale, randomised controlled trial contributes to the limited international evidence on the cost-effectiveness of telecare.

There were some limitations. Some resource use data were not available (e.g. numbers of alerts, types of call-centre responses to participants); numbers of dedicated response visits were not available at the individual level. The proportion of trial participants opting into the questionnaire study differed somewhat between groups (48.3% in telecare and 43.1% in usual care) [9], and numbers in the control group were 16% greater than numbers in the intervention group,

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Table 2. Differences in cost and effect between telecare and usual care groups (12 months)[a], annual equivalent

Values in means (95% CI) unless otherwise stated	Outcomes/total costs (usual care = 378)	Outcomes/total costs (telecare = 375)	Difference in outcomes/total costs/ICER (usual care = 378; telecare = 375)
QALY (adjusted mean[b])	0.325 (0.312, 0.339)	0.329 (0.313, 0.344)	0.003 (−0.018, 0.024)
Cost (adjusted mean[c])	7,610 (6,581, 8,640)	8,625 (7,523, 9,726)	1,014 (−525, 2,553)
ICER (£ per QALY)[b,c,d]	–	–	297,000 (undefined, undefined)
Excluding project management costs			
Cost (adjusted mean[c])	7,605 (6,576, 8,634)	8,522 (7,421, 9,624)	917 (−622, 2,457)
ICER (£ per QALY)[b,c,d]	–	–	269,000 (undefined, undefined)
Excluding dedicated response costs			
Cost (adjusted mean[c])	7,606 (6,577, 8,636)	8,553 (7,451, 9,655)	947 (−593, 2,487)
ICER (£ per QALY)[b,c,d]	–	–	277,000 (undefined, undefined)
Sensitivity analyses			Total costs/ICER
Equipment prices reduced by 50%			
Cost (adjusted mean[c])	7,608 (6,579, 8,638)	8,584 (7,483, 9,685)	975 (−563, 2,514)
ICER (£ per QALY)[b,c,d]	–	–	286,000 (undefined, undefined)
Mainstream support package of £5 per week			
Cost (adjusted mean[c])	7,582 (6,550, 8,613)	8,171 (9,278, 7,065)	590 (−955, 2,134)
ICER (£ per QALY)[b,c,d]	–	–	173,000 (undefined, undefined)
Equipment prices reduced by 50% and mainstream support package of £5 per week			
Cost (adjusted mean[c])	7,580 (6,548, 8,611)	8,131 (7,024, 9,237)	551 (−993, 2,095)
ICER (£ per QALY)[b,c,d]	–	–	161,000 (undefined, undefined)

[a]Cases for which baseline costs data were available.
[b]From SUR analyses (outcome equation), adjusted for baseline utility, site, demographic and individual characteristics (age, sex, ethnicity, IMD, number of chronic conditions, EQ5-D self-care score, previous community alarm, one-person household).
[c]From SUR analyses (cost equation), adjusted for baseline costs, site, demographic and individual characteristics (age, sex, ethnicity, IMD, number of chronic conditions, EQ5-D self-care score, previous community alarm, one-person household).
[d]Rounded to nearest thousand.

raising the possibility of post-randomisation self-selection, a particular threat to cluster-randomised trials; 40% of the control group, and 32% of the intervention group were lost to the 12-month follow-up; these differential attrition rates could have led to a bias in favour of the intervention group. However, baseline characteristics did not differ substantially between available cases at baseline and follow-up within groups. Analyses adjusted for confounders that may have influenced drop-out, and so compensated to some extent for imbalances at follow-up. It remains possible that characteristics not assessed may have created between-group differences at baseline or follow-up, or between completers and non-completers.

Practices of assessing need for telecare were not standardised, with implications for external validity. Telecare services outside the sites may not assess need for telecare in the same way as inside the sites. The very large size of the trial population meant that it would have been impractical to collect and analyse detailed (and largely qualitative) information on variations in assessment practices; by the same token it is likely that within the trial there was a range of assessment models, some of which will have existed outside the sites as well.

Drop-out from the trial into care homes or because of death prior to 12-month follow-up was not considered within these analyses. Costs of health and social care services over the period of the study were estimated by multiplying costs for the 3-month period prior to the 12-month follow-up by four, assuming that across all categories of service use, costs were relatively constant over the year. Other WSD-funded research draws on longitudinal administrative data to examine 12-month mortality, entry into long-term residential or nursing care and costs of a more restricted range of health and social services for trial participants [21]. Mortality rates in that study were similar in both groups (8.9% usual care versus 8.7% telecare), as were rates of permanent admission to care homes (3.2% usual care versus 3.1% telecare).

The assumed impacts of telecare systems require further consideration. To define the impact of telecare in general poses a challenge when the design of systems to support telecare is variable and the technology itself is evolving. The scope of the technology in this evaluation encompassed remote, automatic and passive monitoring systems that go beyond older and more basic forms of telecare focused on summoning assistance (which could form part of standard support and care). The reassurance provided by telecare systems has been said to improve quality of life for users [9, 23, 24]. We chose to use the EQ-5D as it is a generic measure of health-related quality of life that is useful as a basis for comparing alternative technologies [15] and is suitable for use with older populations (cf. [25, 26]). The dimensions of health covered by EQ-5D (self-care, anxiety/depression, usual activities, pain/discomfort, mobility) are relevant to the expected benefits of telecare. However, while the instrument is sensitive to change in situations where changes in health are expected to be substantial [25], this may not be the case with telecare. EQ-5D may not be able to

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capture entirely the improvements brought by telecare. This is because it focuses on the individual's health and restoration of function rather than achievement of benefit through the more compensatory mechanisms provided by much of social care [27] (telecare could be classified as one such service). Benefits may accrue primarily to families and carers of telecare users rather than telecare users themselves (although there is little evidence on impact on quality of life, telecare may reduce carer strain [28]). Any potential beneficial effects on carers that may have resulted from the introduction of the telecare intervention have been excluded from the current analysis. Benefits may particularly accrue to telecare users with certain characteristics. Willingness to use telecare and related assistive technologies may be influenced by concerns about threats to privacy or to identity [29]. Higher costs may be associated with telecare users with particular characteristics; the result of closer monitoring may have prompted *additional* service responses for some people. We plan to explore these issues in quantitative analyses of trial data, in particular, the impact of the technology in carers; qualitative evidence supports important inter-individual differences [cf. 29].

Conclusion

There is great policy interest in the potential of telecare to improve quality of life while decreasing use and costs of health and social care support. However, we found that a package of second-generation telecare equipment and associated monitoring service and (in two sites) a dedicated response service did not constitute a cost-effective alternative to usual care, assuming a commonly accepted willingness to pay for QALYs. For the present, given the lack of robust evidence on cost-effectiveness in favour of telecare, policymakers should avoid characterising this technology as a 'magic bullet' [30].

Acknowledgements

We thank the participants for their time and interest in the study, and all the health and social care managers and professionals in the study sites and the participating case study organisations for their help.

Authors' contributions

C.H., M.K. and J.B. (Beecham) contributed to the planning of economic data collection and administration. C.H. conducted the economic analyses under the supervision of M.K. and J.-L.F. C.H., M.K. and J.-L.F. reported the analyses. H.D., S.P.N., M.K., R.F., J.B. (Barlow), P.B. and A.R. contributed to planning of overall trial design. S.N. is the Principal Investigator for the Whole System Demonstrator trial; H.D. is the guarantor of statistical quality for the trial as a whole. M.K. is the Chief Investigator for the economic evaluation, S.N., S.H., M.B. (Beynon), M.C., L.R. contributed to the planning and administration of questionnaire trial data collection, S.H., M.C., M.B. (Beynon), L.R. and A.S. maintained and provided data on participants. S.H., M.C., M.B. (Beynon), L.R., S.N., A.S., M.B., C.H., M.K. and J.F. contributed to planning of the analyses. All authors reviewed the manuscript. The Evaluation Team met regularly during the trial period and contributed as a whole to discussions of the data under collection.

Conflicts of interest

All authors conform to a competing interest statement and declare: support from the Department of Health and the University College London Hospitals and University College London; several authors have undertaken evaluative work funded by government or public agencies but these have not created competing interests; no other relationships or activities that could appear to have influenced the submitted work.

Ethics approval

The study was approved by the Liverpool Research Ethics Committee, ref: 08/H1005/4.

Funding

This is independently conducted research commissioned and funded by the Policy Research Programme of the Department of Health for England. The views expressed are not necessarily those of the Department.

Supplementary data

Supplementary data mentioned in the text is available to subscribers in *Age and Ageing* online.

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Received 16 July 2013; accepted in revised form 12 March 2014

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