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The implementation of physician assistants in inpatient care: a cost-effectiveness analysis

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ABSTRACT

Objective. To investigate the cost-effectiveness of substitution of inpatient care from medical doctors (MDs) to physician assistants (PAs).

Design. Cost-effectiveness analysis embedded within a multicenter matched-controlled study. The traditional model in which only MDs are employed for inpatient care (MD model) was compared with a mixed model in which besides MDs also PAs are employed (PA/MD model).

Setting: 34 hospital wards across the Netherlands

Participants. 2292 patients were followed from admission till 1 month after discharge. Patients receiving daycare, terminally ill patients and children were excluded.

Primary and secondary outcome measures. All direct healthcare costs from day of admission until one month after discharge. Health outcome concerned quality-adjusted life years.

Results. We found no significant difference for QALY gain (+0.02, 95% CI -0.01-0.05) when comparing the PA/MD model with the MD model. Total costs per patient did not significantly differ between the groups (+ € 568, 95% CI €-254-€1391, p=0.175). Regarding the costs per item, a difference of 309 euro per patient (95% CI €29-€588, p=0.030) was found in favor of the MD model regarding length of stay. Personnel costs per patient for the provider who is primarily responsible for medical care at the ward, was lower on the wards in the PA/MD model (€-11, 95% CI €-16- €-6, p=0.000).

Conclusions. This study suggests that the cost-effectiveness on wards managed by PAs is similar to the care on wards with traditional house staffing. The implementation of PAs may reduce personnel costs, but not overall healthcare costs.

Trial registration: ClinicalTrials.gov Identifier: NCT01835444, April 2013

Key words: Professional role revision, substitution, physician assistant, hospital care, resource use, costs

Strengths and limitations of this study

- This study increases the understanding of the implications of reallocating inpatient care from MDs to PAs on total healthcare costs, as well as on resources uses.
- This study captured a large number of patients from 34 hospital wards, which cover both teaching and non-teaching hospitals and six different medical disciplines
- The non-randomized character of this study implies an increased risk for confounding, which we accounted for in the multivariable analyses and subgroup analyses.
- Although we performed subgroup analyses, we cannot exclude that local differences like policies about quality of care and patient case-mix influence the results.

BACKGROUND

Because of an increased appreciation of continuity of care, pressure to deliver healthcare efficiently, and local shortages of medical doctors (MDs), medical care for admitted patients is increasingly reallocated to physician assistants (PAs).[1-3] A PA is a health professional licensed to practice medicine in defined domains, with variable degrees of professional autonomy.[4] PAs who provide medical care for admitted patients usually work in a team comprising both PAs and MDs (i.e. residents, medical specialists or hospitalists).

Literature suggests that PAs add to the quality of care by increasing continuity for both patients and hospital staff.[1] The turnover of house staff is traditionally high due to use of recent medical graduates who are planning to do fellowships and the mandatory rotational cycles. PAs generally do not rotate and constitute a factor of stability in the continually changing medical workforce. Previous studies show that quality of care for admitted patients delivered by a PA-based team is comparable to that of a resident-based team, and that patient evaluations are at least as good.[5-10] Our own study showed similar quality and safety of care, but better patients experiences on wards with a PA-based team.[11] Estimates of PA employment on costs vary across the conducted studies.[5,6,10] These studies concerned one clinical discipline within one hospital, which reduces the generalizibility of findings. Given the outcomes of these studies and their limitations, we conducted a multicenter study that included PAs providing care to hospitalized patients including a range of clinical disciplines. This paper reports on the cost-effectiveness of substitution of inpatient care from MDs to PAs.

METHODS

Study design

This economic evaluation was performed alongside a multicenter non-randomized matched-controlled study, which was performed in the Netherlands. In this study, the care on wards utilizing a mixed 'PA/MD model' (intervention group) was compared with the care on wards utilizing a solely 'MD model' (control group).

MD model

In the MD model, only MDs are in charge of the admitted patients at a specific hospital department. Most of them are residents. The resident is physically present at the department each weekday and is the first point of access to medical care during office hours (MR model). Their work includes daily clinical care and patient management. The residents are supervised by medical specialists. In some cases, especially in smaller hospitals where often no residents are employed, the medical specialists provide all medical care for the admitted patients (MS model).

PA/MD model

In this model, the PAs who were employed at the wards are substitutes for the residents. Their tasks and responsibilities are largely comparable. PAs have the same authorizations as residents: they can make indications for treatment, perform predefined medical procedures and subscribe medication independently within their field of expertise.[12] We included two different models within the intervention group: a model in which PAs collaborate with residents (mixed PA/MR model) and a model in which only PAs are the first point of access

to medical care (PA model). In both models, the PAs as well as the residents were supervised by medical specialists.

Control wards were matched with the intervention wards on the basis of medical specialty and hospital type. Hospital wards were included in the intervention group if the PA covered at least 51% of the available ward care hours per week during dayshifts on weekdays. Wards were included in the control group if exclusively MDs provided medical care. The primary analysis had patients' length of stay as primary outcome. Further details of the study design have been described elsewhere.[13] The economic analysis was conducted from a healthcare perspective, with a time frame from admission till one month after discharge.

Study population

This study focused on the patients admitted to the hospital wards. Exclusion criteria for patients were: 1) Younger than 18 years; 2) Terminally ill; and 3) Receiving daycare. Daycare was defined as hospital admissions that were intended to last 24 hours or less.

Health outcome

The primary health outcome in this evaluation is the QALY (quality-adjusted life years). A QALY is a generic measure of disease burden.[14] QALYs were derived using the EuroQoL-5D questionnaire (EQ-5D-3L)[15], which is a widely used validated patient questionnaire comprising five domains: mobility, self-care, usual activities, pain, and anxiety/depression. Each domain has three possible levels indicating; no problems, moderate problems or severe problems. The EQ-5D-3L was assessed at three time points: at admission, discharge and one month after discharge. We used the Dutch utility weight to calculate utilities.[16]

Cost outcomes

The primary cost outcome was the sum of direct costs associated with the principal admission and costs that occurred within one month after discharge that were potentially related to hospital admission. Resources used during admission were extracted in detail at an individual patient level from patient medical records and included laboratory tests, diagnostic tests, medication and blood products. Also the frequency and type of consultations of health care suppliers and the number of days of unplanned stay at ICU were derived from the medical records. To minimize information bias, a random sample of 10% of the patient records per ward was reassessed by a second researcher, who was blinded for the results from the initial researcher. In case of an inter-rater agreement of less than 95%, the records of the total sample were reassessed.

Personnel costs included the costs for the residents, PAs and medical specialist who were primarily employed for medical care for the admitted patients. Also the costs for supervision time were included. We measured the number of hours spend for medical ward care per professional by examination of work schedules. All MDs and PAs who had the primary task to provide medical care for admitted patients were asked to fill in their real work schedule during four fixed weeks: week 3, 7, 11 and 15 after the start of the inclusion of patients. Next, we divided the number of working hours by the number of patients for which they were in charge. The number of hours spent for supervision was derived from an online questionnaire. We asked each attending physician for the average number of hours they weekly spend for supervision. These hours were added up for all attending physicians of the department, and divided by the number of patients who were admitted at the ward.

Volumes which were measured between discharge and one month afterwards included days of unplanned readmission, number of presentations at emergency departments, number of contacts with a general practitioner, and the required home care. These volumes were collected from a patient questionnaire that was sent one month after discharge. Costs were calculated by multiplying the volumes of healthcare use with corresponding unit prices, derived from the Dutch Manual for Costing Research.[17] All figures were related to the price level of the same year (i.e. 2014). Details of the costs applied to units of resource use are provided in supplementary table S1.

Sample size calculation

Sample size calculation was based on length of stay (LOS), which was the primary clinical outcome of the multicenter study. Results for LOS have been published elsewhere.[11] The originally published sample size calculation[13] was adjusted prior to start of data collection.[18] To detect a relative difference in LOS of 20% between the 'PA/MD model' and 'MD model', assuming an average LOS of 6 days (SD 4.9), alpha 5%, power 80% and an Intra Cluster Coefficient of 0.06 for patients in same ward, 30 wards including 100 patients each were required. Taking into account an expected drop-out of maximum 2 matched pairs, 34 wards (17 in each arm) with each 100 patients were required. In case of no drop-out, 50 patients per ward would be sufficient.

Data analysis

We used descriptive analyses with counts (and proportions) or means (with SDs) to describe baseline characteristics, effects, and costs. The a priori planned analysis was a comparison between the intervention and control group on incremental costs and incremental effects. The incremental effects were analyzed using a linear mixed model approach with the QALY score

as dependent variable and group and baseline QALY as independent variables, taking clustering of patients within wards into account. If similar effects on the QALY in both groups were found, a cost-minimization approach was performed by comparing differences in costs between groups using a linear mixed model approach accounting for clustering and applying bootstrapping (200 times) to create bias-corrected 95% CIs around the coefficients of the independent variables. A total of 50–200 replications are generally adequate for estimates of standard error.[19] Multivariable models were constructed to adjust for potential confounders. We took matching into account by adding covariables for the matching variables.

Missing data were imputed via multiple imputations. To explore uncertainty around costing assumptions (i.e. cost-prices and salary), sensitivity analysis was conducted on the range of extremes. Imputation models for all cost categories and utility scores were then redone accounting for changes in the sensitivity analysis. To explore heterogeneity within the results, post-hoc subgroup analyses were performed for each submodel of medical ward care: the MS model, MR model, mixed PA/MR model and the PA model. All analyses were carried out with Stata 11.2 (StataCorp, College Station, TX). P-value was set at 0.05 to indicate statistical significance.

Ethical considerations

Ethical approval was received from the Research Ethics Committee of the Radboud university medical center, Nijmegen (registration number: 2012/306); the committee judged that ethical approval was not required under Dutch Law. All data were handled strictly confidential and written informed consent was obtained from all patients.

RESULTS

Between April 2013 and May 2015 we included 1,021 patients spread over 17 hospital wards in the intervention group, and 1,286 patients spread over 17 hospital wards in the control group. More patients in the intervention group were acutely admitted (59% versus 44% in the control group, p< .001). Also medical specialty, hospital type, primary diagnosis and discharge destination differed significantly between the groups (table 1).

Health outcomes

We had complete QALY data for 779 patients in the intervention group (76%) and 982 patients in the control group (76%). Utilities related to the three time points and QALYs are outlined in table 2. The EQ-5D utilities did not statistically significantly differ between the study arms at baseline and throughout the study. At discharge and one month after discharge the mean difference in EQ-5D utility was -0.01 (95% CI -0.06-0.04, p=0.634) respectively -0.04 (95% CI -0.09-0.02, p=0.178), corrected for baseline utility. Similarly, the difference in QALY gain was not statistically significant during admission nor after discharge.

Resource use and costs

Ninety-nine percent of all patient records were assessed. Item-missing varied from 2% (unplanned transfer to ICU) to 9% (use of blood products). Resource use after discharge was derived from the questionnaire which was send to the patient one month after discharge. The response rate on this questionnaire was 76% in both study arms. Resources used during the period from admission till one month after discharge are summarized in supplemental table 2.

Table 3 outlines total costs per patient and costs per item. Mean total costs per patient in the intervention group did not significantly differ from the mean costs per patient in the control

group: mean difference was €568 (95% CI €-254-€1391, p=0.175). Regarding the costs per item, we found significant differences of €309 per patient (95% CI €29-€588, p=0.030) regarding LOS in favor of the MD model. Personnel costs for the PA or MD who is primarily responsible for the medical care at the ward was significantly lower on the wards in the PA/MD model: mean difference €-11 (95% CI €-16- €-6, p=0.000) per patient. Costs for supervision by the staff physicians were significantly higher in the PA/MD model: mean difference €43 (95% CI €39-€47, p=0.000). Since the MD model also incorporates wards with only medical specialists, supervision is not applicable for these wards. To rule out this distortion we performed an additional analysis in which we excluded the 4 wards with only medical specialists. This resulted in an opposite difference: costs for supervision were now significantly lower for the PA/MD model compared to the MD models: mean difference € -11 (€-16- €-6, p=0.000).

Sensitivity analyses on the range of extremes did not change these results of the total costs and costs per item substantially (data not shown, but can be provided on request).

Subgroup analyses

Results for the analyses per submodel of medical ward care are shown in table 4. Mean total costs per patient did not significantly differ among the submodels. Costs for LOS were on average 465 euro per patient (95% CI -920- -10, *P*=0.045) lower in the MS model than in the mixed PA/MR model. The other models did not significantly differ from each other. Personnel costs for the provider who is primarily responsible for the medical care at the ward was significantly highest in the MS model (mean €129 (€37)), and lowest in the PA model (mean €51 (€3)). Costs for supervision were significantly highest in the MR model (mean €178 (€79)) and lowest in the PA model (mean €121 (€59)). We also found significant

differences regarding costs for blood products and required home care: these were highest in the PA model.

DISCUSSION

This study aimed to determine the cost-effectiveness of substitution of inpatient care from MDs to PAs. No significant difference between the two study arms was found on QALY and total costs. Explorative analyses showed a significant difference in costs for LOS in favor of the MD model, and significant differences regarding personnel costs in favor of the PA/MD model.

To our knowledge, this is the first multicenter study that investigated the cost implications of reallocating inpatient care from MDs to PAs. A few single-centered studies have compared costs of non-acute inpatient care delivered by a PA-based team with care delivered by a resident-based team.[5,6,10] These studies did not measure QALYs. Results regarding total costs were mixed. Roy et al.[5] reported that the care by the PA-based team was associated with lower total costs per patient, while Ianuzzi et al.[10] reported an association with higher costs. Singh et al.[6] reported similar costs between the study arms. These studies can however hardly be compared with our study, because different methods to estimate costs were used and the settings were different. In addition, most of these studies compared a hospitalist/PA model with the traditional resident-based model, while hospitalists were not part of the models we used.[20]

Our previous analysis showed increased provider continuity at the ward with the presence of a PA.[20] This study shows that this increased continuity did not cause a decrease in costs, especially because of the higher costs for LOS. Subgroup analysis showed that costs for LOS

were especially higher when compared to the model in which only medical specialists were involved. Costs did not significantly differ between the PA models and the model which involves only residents. An explanation for the lower costs for LOS in the MS model might be that the medical specialists have more work experience. The PA profession is relatively new; most of them have a short time of experience compared to medical specialists.[20] Over time the clinical experience of PAs will become larger, which may lead to lower costs. Besides, we cannot exclude the possibility that the lower LOS indicates that the patients which were included in the MS model were overall less complex than the patients in the other models. Although we've adjusted for relevant confounders in the multivariable analysis, it is not possible to perfectly adjust for the complexity of the patient in non-randomized comparisons.

Personnel costs for the provider who is primarily responsible for the medical care at the ward were significantly lower on the wards with the PA/MD model when compared to the MD model. Subgroup analysis showed highest costs on the wards with only medical specialists. This can be explained by the significant higher salary. Besides, we found lower costs on wards with the PA model when compared to the model which involves only residents. Since the salary of PAs is comparable to the salary of residents (table S1), the significant difference can be explained by our finding that on the wards with the PA/MD model, less time was spend per patient (table S2). This is probably caused by the finding of our previous study that PAs spend less time on indirect inpatient care than residents do.[20] A hypothesis is that since PAs tend to work for a longer time at the hospital ward, they might be more familiar with the clinical protocols and the procedures, for example when requesting diagnostic tests and consultation of other physicians. Also the increased provider continuity might lead to more efficient care.[20]

In our initial analysis, costs for supervision were significantly higher in the PA/MD model when compared to the MD model. However, this finding was biased by the wards with only medical specialists, since supervision was not applicable for these wards. Costs for supervision were higher on the wards with the mixed PA/MR model and the MR model when compared to the PA model. An explanation might be the fact that the PAs in the PA model have more work experience than the PAs and residents in the other models.[21] An alternative hypothesis is that the difference is caused by the teaching culture of the wards. 83% of all included wards with a mixed PA/MR model and 69% of all wards with the MR model are from teaching centers, while none of the wards with the PA model are.[20] As a consequence, there might be more consultation between professionals and more emphasize on education, which could be included in the supervision hours.

This study suggests that the cost-effectiveness of inpatient care delivered by a PA-based team is comparable to that of residents-based teams. This does not confirm the findings from qualitative studies, in which medical specialists experienced an increased efficiency after employing PAs.[21-23] However, the effectiveness which was experienced by the interviewed providers in our own qualitative study was based on items which were not in the scope of this quantitative research.[22] Several interviewees experienced increased effectiveness because the PA performs additional tasks which were normally the responsibility of the staff physicians or residents, like integrating newly employed doctors, performing specific (complex) medical procedures, providing education or conducting quality projects. As a consequence, staff physicians and residents can be employed more effective in for example providing outpatient care or conducting surgery. Besides, residents experience increased effectiveness because they have more time to focus on the needs for their own education.

This economic evaluation was conducted from a health care perspective. The societal perspective was not taken into account. For example, educational costs for PA students are thought to be lower than educational costs for medical students, since the vocational training programs take 2.5 and 6 years respectively. Exact costs for training PA students are however hard to determine, because Dutch PA students have already obtained a healthcare related Bachelor's degree of 4 years and have at least 2 years of clinical work experience in the healthcare domain.[24] Besides, since the PA education is a shortened form of the traditional medical education, it is thought that policy makers can respond quicker on the frequently changing demand for medical professionals within healthcare organizations. Another value from the social perspective might be that becoming a PA is an interesting opportunity for nurses and other health care providers wanting to advance their career.[25,26] As a consequence, motivated employees can be saved for the healthcare workforce.

Several strengths and limitations have to be mentioned. A strength is the multicenter design, which increases the generalizibility of our findings. We included a broad range of clinical disciplines from different types of hospitals. A limitation is the non-randomized design. Different from other countries, the Dutch PA programs incorporate a dual work-education model, which means that students are employed within a particular medical specialty from the day of their enrollment in the master's PA program.[24,27] After graduation, the majority continue their employment at the same department. The suggestion of randomly relocating the graduated PA to another hospital ward could lead to resistance among the staff physicians who put considerable effort in the training. The non-randomized character of this study does imply an increased risk for confounding, which we accounted for in the multivariable analyses. Besides, we tried to reduce heterogeneity within our data by conducting subgroup

analyses for the four models for medical ward care separately. However, we cannot exclude that there are still local differences like policies about quality of care and patient case-mix which still influence our results. Besides, the results of the subgroup analyses should be interpreted with caution because of low numbers of patients per subgroup.

Conclusion

This study suggests that the cost-effectiveness on wards managed by PAs is similar to the care on wards with traditional house staffing by MDs. The implementation of PAs may reduce personnel costs, but not overall healthcare costs.

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Competing interest

The authors declare that they have no competing interest

Data sharing statement

Data files are available from the authors on reasonable request.

Author's contributions

ML and MT are responsible for the design of the study with comments of AvV, MW, EA and GvdB. MT is responsible for the data collection and data management with direct supervision and feedback from ML. MT and EA conducted the data analyses. CvB, KvB, WB, LJ, AV and FvdW were involved in the data collection of the study. MT wrote the first draft of the manuscript and all other authors reviewed this critically. All authors read and approved the final manuscript.

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TABLES

Table 1. Baseline characteristics of patients

Baseline characteristic	PA/MD model (n=1021)	MD model (n=1286)	*P* Value
Medical specialty *n(%)*			<.001
Surgery	601 (59%)	696 (54%)	
Gastroenterology	102 (10%)	181 (14%)	
Pulmonology	91 (9%)	107 (8%)	
Cardiology	101 (10%)	124 (10%)	
Orthopaedics	103 (10%)	100 (8%)	
ENT, head and neck oncology surgery	23 (2%)	78 (6%)	
Hospital type *n(%)*			<.001
Teaching	552 (54%)	709 (55%)	
Academic	23 (2%)	78 (6%)	
Non-academic	529 (52%)	631 (49%)	
Non-teaching	469(46%)	577 (45%)	
Gender, male *n(%)*	524 (53%)	682 (54%)	.47
Age, years *mean ± SD*	64 ± 16	63 ± 15	.11
Major diagnoses *n(%)*			<.001
Digestive system	204 (20%)	247 (19%)	
Circulatory system	158 (16%)	274 (22%)	
Neoplasms	108 (11%)	195 (15%)	
Musculoskeletal system and connective tissue	120 (12%)	119 (9%)	
Injury and poisoning	135 (13%)	80 (6%)	
Infectious and parasitic diseases	59 (6%)	81 (6%)	
Respiratory system	51 (5%)	75 (6%)	
Symptoms	61 (6%)	87 (7%)	
Charlson index for co-morbidity score *mean ± SD*	1.1 ± 1.8 (43%)	1.1 ± 1.8 (44%)	.65
(% with score ≥1)			.66
Highest education *n(%)*			.15
Low	371 (38%)	422 (34%)	
Middle	380 (39%)	489 (40%)	
High	233 (24%)	328 (27%)	
Ethnicity, Dutch *n(%)*	976(99%)	1212 (98%)	.15
Marital status *n(%)*			.29
No partner	136 (14%)	167 (14%)	
Partner	730 (74%)	949 (77%)	
Widow	119 (12%)	125 (10%)	
Smoking status *n(%)*			.65
No, never smoked	325 (33%)	385 (31%)	
No, but ever smoked	494 (48%)	626 (50%)	
Yes, still smoking	174 (17%)	230 (19%)	
Body Mass Index *(mean ± SD)*	27 ± 5	27 ± 5	.79
Number of hospitalizations for same problem *n(%)*			.20
1 hospitalization	580 (59%)	693 (56%)	
>1 hospitalization	403 (41%)	540 (44%)	
Type of admission *n(%)*			<.001
Elective	402 (41%)	687 (56%)	
Urgent	588 (59%)	547 (44%)	
Discharge destination *n(%)*			<.001
Home	765 (90%)	965 (92%)	
Hospital	12 (1%)	30 (3%)	

Nursing home/rehabilitation center/hospice	56 (7%)	28 (3%)
Family relative	18 (2%)	25 (2%)

Note: Numbers may not add up to the total because of missing values

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Table 2. Utilities at admission, discharge and one month after discharge, and QALY gained

Outcome	PA/MD model (n=1,015) *mean (SD)**	MD model (n=1,277) *mean (SD)**	Difference *mean (95% CI)*	*P* Value
EQ-5D				
Baseline (admission)	0.64 (0.28)	0.68 (0.29)	-0.04 (-0.12-0.03)	0.247
Discharge	0.71 (0.22)	0.72 (0.23)	-0.01 (-0.06-0.04)	0.634
One month after discharge	0.75 (0.23)	0.78 (0.22)	-0.04 (-0.09-0.02)	0.178
QALY gain during admission	0.07 (0.25)	0.04 (0.25)	0.03 (-0.02-0.08)	0.213
QALY gain after discharge**	0.04 (0.22)	0.05 (0.21)	-0.02 (-0.07-0.02)	0.216

*Values are summary estimates obtained by multiple imputation

**Difference in QALY between 1 month after discharge and discharge, adjusted for baseline utility

Table 3. Total costs per patient and costs per item (€)

Item	PA/MD model (n=1015) *mean (SD)**	MD model (n=1277) *mean (SD)**	Difference ** *mean (95% CI)*	*P Value*
Costs associated with principal admission				
Length of stay	1780 (1811)	1421 (1210)	309 (29-588)	0.030
Non-elective transfer to ICU	333 (3267)	182 (1761)	105 (-262-473)	0.575
Resources used during admission				
Medication	344 (848)	243 (748)	99 (-9- -207)	0.073
Laboratory tests	107 (168)	99 (136)	19 (-16-44)	0.366
Diagnostic tests	163 (229)	154 (235)	-1 (-44-42)	0.970
Blood products	31 (122)	36 (117)	-12 (-37-14)	0.371
Consultation with health care suppliers				
Medical or surgical consultant	30 (93)	19 (47)	4 (-6-13)	0.437
Paramedics and specialist nurses	96 (159)	73 (121)	14 (-20- 48)	0.429
Personnel				
PA/MD who is primarily responsible for medical care	71 (29)	103 (44)	-31 (-33- -28)	0.000
Supervision by staff physician	156 (93)	129 (104)	43 (39- 47)	0.000
Exclusion of wards with staff physicians only	156 (93)	173 (77)	-11 (-16- -6)	0.000
Costs occurred during first month after discharge				
Presentation at emergency department	108 (182)	114 (298)	-13 (-45-20)	0.448
Non-elective readmission	456 (1333)	421 (1142)	1 (-89-92)	0.977
Contact with general practitioner	55 (73)	53 (70)	0 (-7-7)	0.923
Required home care	121 (248)	98 (214)	11 (-9-30)	0.275
Total costs	**3480 (5196)**	**2869 (3260)**	**568 (-254-1391)**	**0.175**

Abbreviations: PA = physician assistant; MD=medical doctor

*Values are summary estimates obtained by multiple imputation

**Difference in mean costs per patient in the PA/MD group minus the MD group with bootstrapped 95% CI, adjusted for medical specialty, hospital type, diagnosis, comorbidities, type of admission, discharge destination

524 Table 4. Costs (€) per patient per submodel of medical ward care

Item	PA/MD model (n=1015)		MD model (n=1277)		*P* Value **
	PA/MR model (n=698) *mean (SD)**	**PA model (n=317)** *mean (SD)**	**MR model (n=924)** *mean (SD)**	**MS model (n= 353)** *mean (SD)**	1= PA/MR model 2=PA model 3= MR model 4= MS model
Costs associated with principal admission					
Length of stay at the ward	1921 (1949)	1469 (1413)	1557 (1335)	1064 (675)	1 vs 4: *P* = 0.045
Non-elective transfer to ICU	468 (3935)	45 (494)	249 (2072)	17 (322)	NS
Resources use during admission					
Medication	365 (943)	297 (600)	280 (869)	130 (194)	NS
Laboratory tests	116 (167)	85 (170)	114 (149)	58 (78)	NS
Diagnostic tests	202 (253)	73 (121)	152 (249)	155 (195)	NS
Blood products	16 (89)	61 (171)	33 (130)	42 (71)	1 vs 2: *P* = 0.001 3 vs 2: *P* = 0.006
Consultation with health care suppliers					
Medical or surgical consultant	35 (108)	18 (41)	21 (50)	11 (30)	NS
Paramedics and specialized nurses	97 (175)	94 (120)	72 (130)	73 (90)	NS
Personnel					
PA/MD who is primarily responsible for medical care	80 (31)	51 (3)	93 (42)	129 (37)	1 vs 4: *P* = 0.000 2 vs 4: *P* = 0.000 3 vs 4: *P* = 0.006 1 vs 3: *P* = 0.000 2 vs 3: *P* = 0.000 2 vs 1: *P* = 0.008
Supervision by staff physician	173 (100)	121 (59)	178 (79)	NA	1 vs 3: *P* = 0.019 2 vs 3: *P* = 0.000 2 vs 1: *P* = 0.000
Costs occurred during first month after discharge					
Presentation at emergency department	112 (182)	101 (182)	125 (296)	88 (307)	NS
Non-elective readmission	455 (1176)	467 (1647)	438 (1054)	388 (13564)	NS
Contact with general practitioner	57 (75)	53 (69)	54 (72)	51 (67)	NS
Required home care	109 (222)	150 (298)	104 (229)	86 (174)	2 vs 1: *P* = 0.029 2 vs 3: *P* = 0.031 2 vs 4: *P* = 0.025
Total costs	3807 (5997)	2754 (2536)	3154 (3625)	2120 (1809)	NS

Abbreviations: PA = physician assistant; MR=medical resident; MS=medical specialist; NS= not significant; NA= not applicable

*Values are summary estimates obtained by multiple imputation

525 **Only significant p-values are noted

526

FIGURES

Figure 1. Flow-chart of patients

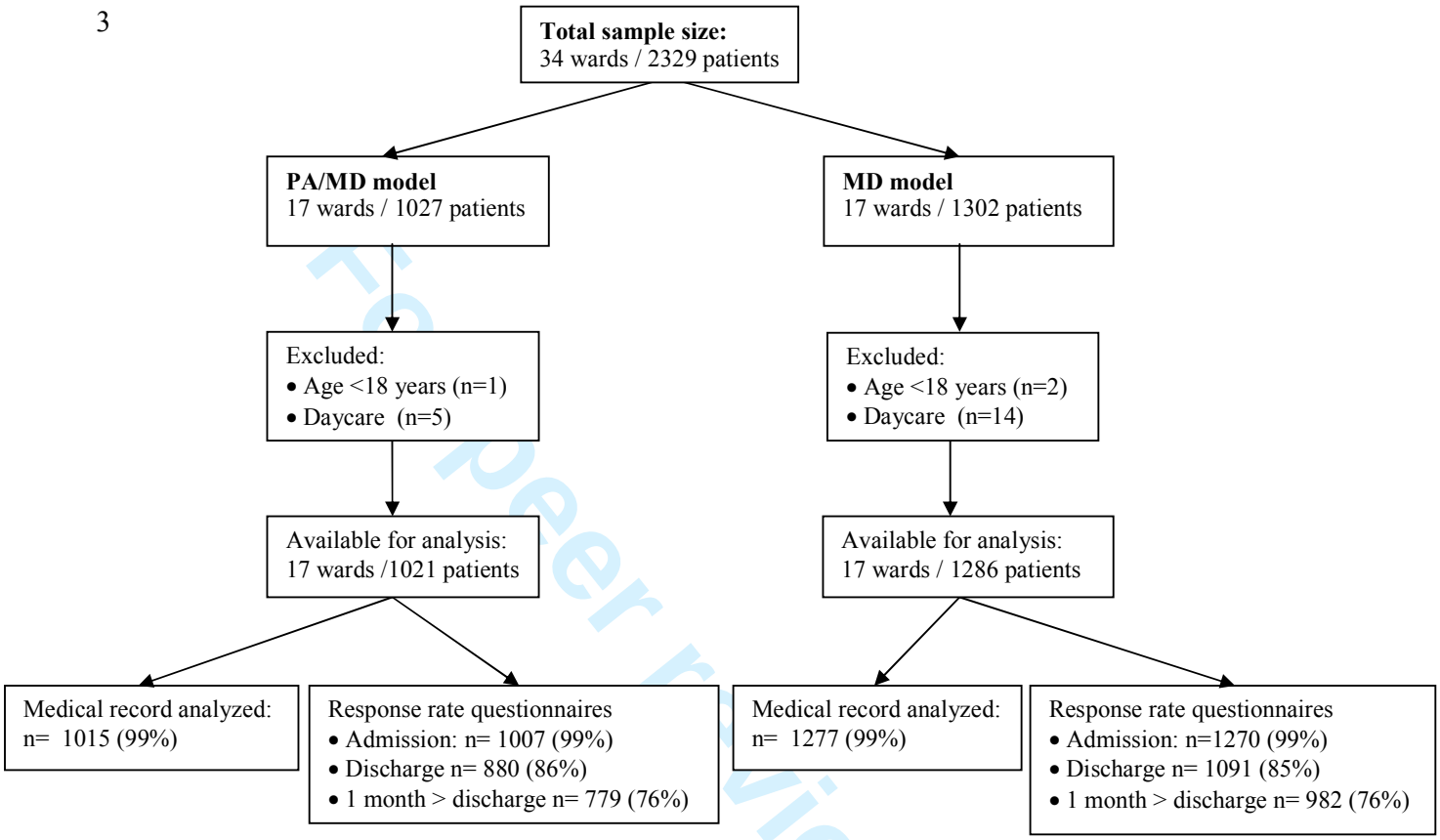

Table S1. Details of the unit costs (year 2014) assigned to health care resource use data

Health care use	Unit cost	Unit	Details	Source
Admissions				
Ward	€210	Per day	Average price, including overhead costs, but not personnel costs and costs regarding resource use	Dutch manual for costing[1]
Intensive care unit	€2015	per day	Average price per day including all costs: personnel, resource use, overhead	Dutch manual for costing[1]
Resource use during admission				
Medication	Variable	Per unit	Minimum and maximum cost price, variable per type and dose of medicine	www.medicijnkosten.nl
Laboratory tests	€1.77	Per test	Average price per laboratory test	Dutch manual for costing[1]
Investigations. For example:	Variable	Per investigation	Variable per type of investigation	The Dutch Healthcare Authority (NZa)[2]
X-ray of the thorax	€55,81	Per x-ray	Fixed price established by the NZa	The Dutch Healthcare Authority (NZa)[2]
CT scan of the abdomen	€234,57	Per scan	Fixed price established by the NZa	The Dutch Healthcare Authority (NZa)[2]
MRI Cerebrum	€253.89	Per MRI	Fixed price established by the NZa	The Dutch Healthcare Authority (NZa)[2]
DEXA scan	€109.09	Per scan	Fixed price established by the NZa	The Dutch Healthcare Authority (NZa)[2]
Blood products				
Erytrocytes	€216	Per unit (280 ml)	Fixed price, established by Sanquin Blood Supply	Dutch manual for costing[1]
Trombocytes	€522	Per unit (330 ml)	Fixed price, established by Sanquin Blood Supply	Dutch manual for costing[1]
Plasma	€186	Per unit (310 ml)	Fixed price, established by Sanquin Blood Supply	Dutch manual for costing[1]
Consultation with health care suppliers				
Medical or surgical consultant	€27	per consult	Based on an assumed session time of 12 minutes	Dutch manual for costing[1]
Physiotherapist	€33	per consult	Based on an assumed session time of 30 minutes	Dutch manual for costing[1]
Occupation therapist	€33	per consult	Based on an assumed session time of 30 minutes	Dutch manual for costing[1]
Dietician	€27	per consult	Based on an assumed session time of 30 minutes	Dutch manual for costing[1]
Speech therapist	€30	per consult	Based on an assumed session time of 30 minutes	Dutch manual for costing[1]
Social worker	€30	per consult	Based on an assumed session time of 30 minutes	Financial department Radboud university medical center
Specialized nurse	€30,5	per consult	Based on an assumed session time of 30 minutes	Dutch manual for costing[1]
Psychologist	€64	per consult	Based on an assumed session time of 60 minutes	Dutch manual for costing[1]
Personnel				

PA/MD who is primarily responisble for medical care at the ward				
Resident	€36.24	per hour	Based on a contract of 46 hours per week (including time for education) , a salary of €4365 and 39% addition for honorarium	Dutch manual for costing[1]
Physician Assistant	€39.82	per hour	Based on a contract of 36 hours per week, a salary of €3719 and 39% addition for honorarium	Dutch manual for costing[1]
Staff physician	€116	per hour	Based on an average salary, including honorariums	Dutch manual for costing[1]
Supervision by staff physician	€116	per hour	Based on an average salary, including honorariums	Dutch manual for costing[1]
Resource use during first month after discharge				
Visit to emergency department	€259	per visit	Average price per visit	Dutch manual for costing[1]
Readmission	€476	per day	Average price including all costs, independent of type of medical specialty	Dutch manual for costing[1]
Contact with GP				
GP surgery visit	€33	per consult	Based on a consult time of maximum 20 minutes	Dutch manual for costing[1]
GP home visit	€50	per consult	Based on a consult time of maximum 20 minutes	Dutch manual for costing[1]
Phoned GP for advice	€17	per consult	Based on a consult time of maximum 10 minutes	Dutch manual for costing[1]
Consult at GP cooperative	€87.41	per consult	Average price per visit	The Dutch Healthcare Authority (NZa)
Required home care				
Nursing home care	€73	per hour	Average price per hour	Dutch manual for costing[1]
Domestic home care	€23	per hour	Average price per hour	Dutch manual for costing[1]

Abbreviations: GP = General Practitioner

1. Hakkaaer- van Roijen L, Tan S, Bouwmans CAM: Handleiding voor Kostenonderzoek. Methoden en standaard kostprijzen voor economische evaluaties in de gezondheidszorg. In. Rotterdam: Health care Insurance Council; 2015
2. http://dbc-zorgproducten-tarieven.nza.nl/nzaZpTarief/ZoekfunctieDot.aspx

Table S2. Resources use during admission and one month after discharge

Item	PA/MD model (n=1015)	MD model (n=1277)
Admission		
Length of stay	6 (4-10)	5 (4-8)
Days, median (IQR)		
Non-elective transfer to ICU		
Days, median (IQR)	0 (1-2)	0 (1-1)
n/N (%)	19/987 (2%)	23/1242 (2%)
Resources use during admission		
Medication	Variable	Variable
Laboratory tests		
Number of items analyzed, median (IQR)	31 (8-66)	34 (8-71)
n/N (%)	870/954 (91%)	1130/1254 (90%)
Diagnostic investigations		
number of investigations, median (IQR)	1 (0-3)	1 (0-2)
n/N (%)	692/932 (74%)	711/1143 (62%)
Blood components		
number of blood components, median (IQR)	0 (0-0)	0 (0-0)
n/N (%)	64/998 (6%)	54/1097 (5%)
Consultation with health care suppliers during admission		
Medical or surgical consultant		
number of consultation, median (IQR)	0 (0-1)	0 (0-0)
n/N (%)	281/912 (31%)	297/1256 (24%)
Paramedics and specialist nurses		
number of consultation, median (IQR)	1 (0-4)	0 (0-2)
n/N (%)	554/953 (58%)	612/1246 (49%)
Personnel		
PA/MD who is primarily responsible for medical care at the ward	1.80 (0.93)	1.98 (1.60)
hours, mean (SD)		
Supervision by staff physician	1.34 (0.80)	1.11 (0.90)
hours, mean (SD)		
Exclusion of wards with staff physicians only	1.34 (0.80)	1.53 (0.68)
Resources use during first month after admission		
Presentation at emergency department		
number of presentations	0 (0-0)	0 (0-0)
n/N (%)	119/743 (16%)	169/941 (18%)
Non-elective readmission		
Days, median (IQR)	0 (0-0)	0 (0-0)
n/N (%)	66/738 (9%)	77/935 (8%)
Contact with general practitioner		
number of contacts	1 (0-2)	1 (0-2)
n/N (%)	214/577 (54%)	394/702 (56%)
Required nursing home care		
Hours, median (IQR)	0 (0-1)	0 (0-0)
n/N (%)	97/589 (16%)	91/713 (13%)
Required domestic home care		
Hours, median (IQR)	0 (0-0)	0 (0-0)
n/N (%)	118/741 (16%)	169/941 (18%)

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any pre-specified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-9
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6-7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-9
Bias	9	Describe any efforts to address potential sources of bias	6-10
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	10
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	10

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11 Figure 1
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11 24 (Table 1)
		(b) Indicate number of participants with missing data for each variable of interest	24 (Table 1)
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	11-12
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-12 26 (Table 2 and 3)
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	27 (Table 4)
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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BMC Health Services Research

STUDY PROTOCOL Open Access

The effectiveness of substitution of hospital ward care from medical doctors to physician assistants: a study protocol

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Abstract

Background: Because of an expected shrinking supply of medical doctors for hospitalist posts, an increased emphasis on efficiency and continuity of care, and the standardization of many medical procedures, the role of hospitalist is increasingly allocated to physician assistants (PAs). PAs are nonphysician clinicians with medical tasks. This study aims to evaluate the effects of substitution of hospital ward care to PAs.

Methods/Design: In a multicenter matched controlled study, the traditional model in which the role of hospitalist is taken solely by medical doctors (MD model) is compared with a mixed model in which a PA functions as a hospitalist, contingent with MDs (PA/MD model). Twenty intervention and twenty control wards are included across The Netherlands, from a range of medical specialisms. Primary outcome measure is patients' length of hospital stay. Secondary outcomes include indicators for quality of hospital ward care, patients experiences with medical ward care, patients health-related quality of life, and healthcare providers' experiences. An economic evaluation is conducted to assess the cost implications and potential efficiency of the PA/MD model. For most measures, data is collected from medical records or questionnaires in samples of 115 patients per hospital ward. Semi-structured interviews with healthcare professionals are conducted to identify determinants of efficiency, quality and continuity of care and barriers and facilitators for the implementation of PAs in the role of hospitalist.

Discussion: Findings from this study will help to further define the role of nonphysician clinicians and provides possible key components for the implementation of PAs in hospital ward care. Like in many studies of organizational change, random allocation to study arms is not feasible, which implies an increased risk for confounding. A major challenge is to deal with the heterogeneity of patients and hospital departments.

Trial registration: ClinicalTrials.gov ID NCT01835444

Keywords: Substitution, Task reallocation, Hospitalist, Physician assistant, Costs, Quality

Introduction

Background

Healthcare systems across the world face a number of challenges, such as a rising demand for healthcare services, a growing number of chronic ill patients and rising patient expectations. Concurrently, the supply of medical doctors (MDs) is constrained in most countries, leading to workforce shortages [1]. Nonphysician clinicians have been introduced into the medical domain in order to take over tasks from MDs [2]. An example of a nonphysician clinician is the Physician assistant (PA), a health care professional licensed to practice medicine in defined domains, in collaboration with MDs but with a substantial degree of professional autonomy [3]. PAs obtain medical history, perform physical examinations, request and interpret additional testing, render medical diagnoses and treatment procedures, and prescribe medication. They also perform specific medical procedures, such as endoscopies, catheterizations, elective cardioversion and minor surgeries [3,4]. In addition, PAs contribute to the quality of care by

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developing protocols, initiate or participate in quality projects and education programs [5].

The PA was first introduced in the sixties in the United States and then rapidly spread across the country [4]. In the Netherlands, the first PAs were introduced in 2001 [6,7]. Currently approximately 630 graduated PAs are employed in the Dutch healthcare system, on a total of about 65 000 registered physicians [8]. In the next few years, about 120 PAs will yearly complete their Master program. Contrary to the USA, where the majority of PAs work in primary care settings, most Dutch PAs (about 75%) work in the hospital settings [9]. The majority works at general surgery, surgical subspecialties, cardiology, anesthesiology or internal medicine [10]. The main features of Dutch PA's are [7,10]:

- PAs follow a 30 month training program at a Master's degree level.
- The Dutch PA programs incorporate a dual work-education model, which means that students are employed within a particular medical specialty while enrolled in the master's PA program. The students undertake didactic and clinical education within this medical specialty from the beginning till the end of the curriculum.
- PA students are professionals with a health care-related bachelor's degree and at least 2 years of clinical work experience in the health care domain.
- PAs conduct low to moderately complex medical tasks within a certain specialty, both in primary and secondary care. Most PAs practice in the hospital setting.
- Since January 2013, PAs are authorized to indicate and perform predefined medical procedures and subscribe medication without supervision. The scope of practice will be re-evaluated in 2017.
- Physician Assistant is a protected title by law. The legislation is written in the Individual Health Care Professions Act (Wet BIG), article 36a.

Since the first introduction of the PA, several studies have examined their performance. This body of evidence suggests that PAs can provide high-quality care in a large range of medical disciplines [11-14]. The studies indicate that they provide care that is comparable to that of MDs, with high levels of patient satisfaction [15-18]. Although there is international evidence for both efficacy and effectiveness supporting the reallocation of care from MDs to PAs, current research does not cover all settings and professions [2,13]. Many studies concern primary and critical care settings, while studies assessing the effects of substitution of non-acute inpatient medical care are limited. Some studies show methodological limitations like single centered, non-randomized, a relatively small sample size or no control condition. Besides, concerns have been expressed regarding potential adverse effects of involving PAs, such as negative impacts on patient safety and continuity of healthcare delivery.

In this study we focus on patients admitted to a hospital, who are taken care by a hospitalist. Hospitalists are responsible for the coordination of the daily medical care of hospitalized patients [19]. This role has traditionally been fulfilled by medical residents (MRs) and occasionally by medical specialists. In recent years, the role of hospitalist has been increasingly reallocated to PAs [3,11], facilitated by technological innovations and the standardization of many medical procedures by clinical protocols [20,21]. In 2013, approximately 200 graduated PAs were employed as hospitalist in the Netherlands. When PAs are employed as hospitalists, the applied model to cover 24/7 ward care is often a mixed model that contains both PAs and MDs as hospitalist, comprising a patient medical care team. The tasks of PAs in such a team are comparable to those of the MDs. The PAs, however, tend to work during daytime on weekdays, while MDs often work during evenings, nights and weekends. It is anticipated that within the next decades PAs will be increasingly employed in the management of hospitalized patients for a range of different specialism. However, empirical evidence about the consequences of reallocating medical ward care from MDs to PAs for the quality and safety of care is currently limited.

Study aim

The primary aim of this study is to determine the effectiveness of hospital ward care by MDs compared to a patient medical care team consisting of both PAs and MDs. It is hypothesized that due to reallocation of care to a fixed number of PAs per hospital ward, inpatient care becomes more standardized and continued resulting in improved care, which will be reflected by shorter hospital stay. To measure effectiveness we therefore choose length of hospital stay (LoHS) as primary outcome measure. Besides the effectiveness, also the effects on quality and continuity of care and patient and care provider experiences are investigated.

Methods/Design

Study design and population

A multicenter non-randomized matched-controlled study is performed in The Netherlands, comparing wards utilizing a mixed 'PA/MD model' (intervention group) with wards utilizing a solely 'MD model' (control group, usual care). Control wards are matched with the intervention wards on the basis of medical specialism and hospital type (i.e. academic versus non-academic). Data collection runs parallel for each pair of matched intervention and control ward, with a maximum deviation of two weeks.

Study setting

Hospital wards are being assigned to the intervention group if the PA has completed an accreditated master's PA degree and covers at least 51% of the available ward care hours per week during dayshifts (8 h-18 h) on weekdays. Wards are assigned to the control group if solely MDs fulfill the hospitalist position. Exclusion criteria at ward level are: 1) Nurse practitioners (including in training) in the role of hospitalist; 2) Only non-graduated PAs in the role of hospitalist; 3) Psychiatric and pediatric wards and intensive care units. In order to enhance the generalizability of findings we include a heterogeneous sample of hospitals across the country and a mix of medical specialism.

Study population

The focus of this study is on the patients admitted to the included hospital wards. Exclusion criteria at patient level are: 1) Patients younger than 18 years; 2) Terminally ill patients; 3) Patients in daycare. Daycare is defined as hospital admissions which are intended to last 24 hours or less. For patients who are not able to fill in questionnaires (e.g. patients with cognitive impairment), family relatives are asked to fill in the questionnaires. Besides the patients, also the PAs, MDs, and a sample of ten nurses who are employed at the included ward are involved as study objects. The sample of nurses is established by selecting the first ten nurses who are scheduled for a dayshift during the third week from data collection.

Primary outcome

LoHS is the primary outcome measure. Reducing LoHs is important for payers of healthcare and for many patients. LoHS is defined as the time period in days between date of discharge and date of admission. To control for discharge delay for nonmedical reasons, i.e. delay attributable to waiting times for a place in a nursing home or a rehabilitation clinic, or help in the patient's own home, we also register the date of completion of medical treatment in the hospital.

Secondary outcomes

Quality of hospital ward care

To assess the quality of ward care, a set of eleven global clinical and process indicators has been selected from the literature and suggestions by a physician panel. The clinical indicators were derived from a national set of indicators for quality of hospital care from the Dutch Health Care Inspectorate (IGZ) [22]. All indicators cover a period of maximum one month after discharge. The selected indicators are:

Clinical indicators:

- Inhospital mortality
- Unplanned transfer to intensive care unit
- Cardiopulmonary resuscitation
- Pressure sore developed during admission
- Fever: number of days body temperature ≥38
- Pain score: number of days Numeric Rating Score ≥7
- Hospital infections: infusion-, urinary track-, airway-, and postoperative wound infections
- Presentation at department of emergency, within one month after discharge
- Non-elective readmission within one month after discharge

Process indicators:

- Days between discharge and letter of discharge
- Introduction hospitalist to the patient less than 24 hours after hospital admission

Data about unplanned readmission and presentation at emergency department after discharge are collected using self-administered patient questionnaires, which are send at one month after discharge date. Information about the other indicators will be retrospectively derived from patient medical records.

Patients health-related quality of life

Generic health-related quality of life is measured with the Euroqol-5D (EQ-5D), which is a widely used validated questionnaire containing five domains: mobility, self-care, usual activities, pain, and anxiety/depression [23]. Each domain has three possible levels indicating; no problems, moderate problems or sever problems. Besides, respondents are asked to value their overall health status on a visual analog scale, ranging from 0 (defined as the worst imaginable health state) to 100 (defined as the best imaginable health state). The EQ-5D is assessed by patient questionnaires at three time points: at admission, discharge and one month after discharge.

Patient experiences with medical ward care

Patient experiences with medical ward care are assessed by a self-administered questionnaire at discharge. This questionnaire focuses on satisfaction with communication, experienced continuity of care and cooperation, and the patients view on the medical competencies of the hospitalist. Patient perceptions on communication skills of the hospitalist are measured with the Communication Assessment Tool (CAT), which consists of 15 questions and can be rated on a 5 point Likert scale, ranging from 'poor' to excellent'. Although not validated in the Netherlands, the CAT has already proven to be a reliable and valid instrument in the hospital setting in the US [24]. Three subscales from the 'Chronically Ill Patients Evaluate general Practice' (CEP) questionnaire were added to measure the items satisfaction with continuity of care, cooperation of ward care providers, and medical competencies of the

hospitalist [25]. Each item will be rated on a six point Likert scale, ranging from 'poor' to 'excellent'. As this questionnaire has only been validated for primary care, psychometric properties will be examined in this study. To ensure that patients know who their hospitalist is, we include photos from the hospitalist(s) in the questionnaire. To assess whether patients understood the questions asked in the self-administered questionnaires, we pre-tested the questionnaire in a sample of ten patients admitted to two hospital wards in different hospitals.

Health professionals' work experiences and job characteristics

An online questionnaire is compiled to measure job satisfaction, distress outcomes and other job characteristics of the care providers working at the included hospital wards; i.e. all MDs and PAs who fulfill the role of hospitalist, and a random sample of ten nurses in each of the participating wards.

Job satisfaction is assessed with the McCranie Job Satisfaction Scale, which consists of 13 questions which can be rated on a 6-point Likert scale, ranging from very dissatisfied to very satisfied [26]. The questionnaire addresses satisfaction with the amount of time which is available per patient, satisfaction with the level of work challenge, and satisfaction with the collaboration with nurses, medical specialists and medical residents. Some items were rephrased to make them appropriate for the specific profession of our interest and some questions were added. For all professions we additionally ask about satisfaction with collaboration with PAs. Besides, in the questionnaire for medical specialists a question about satisfaction with time spend on supervision was added, and in the questionnaire for hospitalists we additionally ask for satisfaction with the received supervision. Finally, respondents are asked to value their overall job satisfaction on a visual analog scale, ranging from 1 (extremely unsatisfied) to 10 (extremely satisfied).

Job stress is assessed by the 12-item General Health Questionnaire (GHQ-12). The GHQ-12 is a unidimensional, validated scale which comprises questions regarding anxiety, depression, social dysfunction, and loss of confidence. Statements are rated on a 4-point rating scale (symptom present: "not at all" = 0, "same as usual" = 0, "more than usual" = 1, and "much more than usual" = 1) GHQ-12 scores range from 0 to 12 with a higher score indicative of poorer psychological well-being [27].

Workload of hospitalists is measured in terms of number of patients seen per day and weekly overtime hours. We ask hospitalists (both PAs and medical residents) and medical specialists for the number of hours per week spend on both direct and indirect patient contacts at the hospital ward, and the number of hours per month spend on non-patient related tasks like participating in quality and patient safety projects and performing scientific research. In the questionnaire for hospitalists we additionally ask for the number of hours spend on patient related non-hospitalist tasks like performing medical procedures or supporting outpatient care. Besides, we ask the hospitalists how much supervision time they obtain, and the medical specialists how many time they spend on supervision.

Continuity of care

Effects of substitution of hospital ward care on patient experienced continuity of care are measured by a set of questions in the patient questionnaire at discharge, as described in the section 'patients experiences with medical ward care'. Additionally, continuity of care is established by evaluating work schedules. All hospitalists are asked to fill in their real work schedule during fixed weeks: week 3, 7, 11 and 15 after the start of the inclusion of patients. Continuity of care will be assessed by counting the number of rotations in the hospitalist position during these fixed four weeks. Data collection runs parallel for each pair of matched intervention and control ward.

Qualitative research

Semi-structured interviews are conducted to identify determinants which contribute to the safety, clinical effectiveness and cost-effectiveness of hospital ward care by PAs. Also barriers and facilitators for the implementation of PAs in the role of hospitalist are explored. The interviews are held with a sample of PAs, (specialized) MDs, heads of the departments and nurses. Sampling is done purposively. A variety of care providers are include, covering different medical specialties and medical ward care models. Interviews will be taken until data saturation is achieved on the basis of interim-analyses after each set of five to eight interviews, with a minimum of twenty interviews. A topic list, which will be refined iteratively during the process of data collection and analysis, is used to frame the interview. The TICD framework of Flottorp et al is used to standardize the reporting of barriers and facilitators [28]. Barriers are analyzed in the context of the innovation itself, the individual professional and the patient, and the social context, the organizational context and the economic and political context.

Economic evaluation

To assess the cost implications and efficiency of substitution of hospital ward care from MDs to teams with PAs, an economic evaluation is conducted alongside the outcomes evaluation. This economic evaluation is based on the general principles of a cost-effectiveness analysis, except that the time horizon per included patient is limited to one month after discharge. If equivalence of

effects is established the economic decision rule alters in 'cost minimization'. The primary cost outcome for the economic evaluation is costs associated with the principal admission (LoHS, resource use, consultation of health care suppliers, salaries, productivity loss) and costs that occurred after discharge that is potentially related to hospital ward care (unplanned readmission, presentation at emergency departments, visits of general practitioner, required home care, productivity loss) in a period from admission until one month after discharge (Table 1). The primary effect outcome in the economic evaluation is EQ-5D based QALYs. We will also analyze costs in relation to LoHS, the primary outcome in the outcomes evaluations. Besides these costs and effects, information about patient characteristics such as gender, age, primary diagnoses and co-morbidities are collected in order to account for patient case-mix as far as possible. All patient-related volumes are collected in detail at an individual patient level, primarily from medical patient records and patient and care provider questionnaires. Costs will be calculated by multiplying the volumes of healthcare use with corresponding unit prices, derived from the Dutch Manual for Costing Research [29], which also include organizational overhead costs. All figures will be related to the price level of the same year.

Table 1 Volumes included in the economic evaluation

Volume	Unit
During hospital stay at the included ward*	
Length of hospital stay	Number of days
Non-elective transfer to ICU	Number of days
Resource use:	
Surgery	Type of surgery
Medication	Frequency, dose and type of medicine
Laboratory tests	Frequency and type of blood test
Radiographic imaging	Frequency and type of radiographic imaging
Scopic tests	Frequency and type of scopic test
Blood components	Number of units
Consultation with health care suppliers‡	Number of consultations
Medical ward staff:	
Hospitalists	Working hours per week hospitalist
Supervision by medical specialist	Number of hours supervision per week
During the first month after discharge†	
Non-elective presentation at emergency department after discharge	Number of presentations at emergency department
Non-elective readmission	Number of days
Non-elective visit to GP	Number of visits to GP post
	Number of visits by GP at patient's home
	Number of visits to GP
	Number of telephone contacts with GP
Required nursing home care	Number of hours per week
Required domestic home care	Number of hours per week
Productivity loss	Hours per week

Abbreviations: *ICU* Intensive Care Unit, *GP* General Practitioner.
*Assessed by extraction of patient medical records.
†Assessed by patient questionnaires one month after discharge.
‡e.g. medical specialist, physiotherapist, dietician, diabetes nurse, occupational therapist, medical social work, psychologist.

Confounders

Because of the non-randomized character of this study and the heterogeneity of patients and hospital wards, there is a risk of confounding. We will correct for a number of predefined confounders in the statistical analyses. The covariables related to *patients* are: gender, age, education, ethnicity, marital status, smoking status, body mass index, primary diagnosis, co morbidities, number of prior hospitalizations, type of admission (elective or emergent), discharge destination and the health-related quality of life at admission. *Healthcare provider factors* are gender, age, highest education, profession, years since graduation, years on the job, extent of employment, regularity of work schedules and workload. *Hospital ward characteristics* are medical specialism, hospital type, teaching status, number of admissions, bed occupancy, and number of MDs, PAs and nurses are assessed. Covariables are extracted from patient medical records and patient and care provider questionnaires.

Sample size calculation

To detect a relative difference in LoHS of 20% between the mixed 'PA/MD model' and solely 'MD model', assuming an average LoHS of 7 days [30], alpha 5%, power 80% and an ICC of 0.06 for patients in same ward, 40 wards including 100 patients each are required. Taking into account an expected drop-out rate of 10% at the level of wards, and a 10% drop out rate of patients (withdrawal of informed consent), 44 wards (22 in each arm) with each 115 patients are included. The number of in depth interviews depends on the moment data saturation is attained.

Data analyses

To compare hospital wards utilizing a mixed 'PA/MD model' with wards utilizing a solely 'MD model', we use logistic regression analyses for dichotomous outcomes and linear regression analysis for continuous outcomes, both with random coefficients to account for statistical clustering of data in hospital wards. The analysis is on

an intention to treat basis and matching will be taken into account. Missing values are substituted by multiple imputation techniques. Multivariable models are constructed to correct for potential confounders. Covariables are included in the final model only if they modify the regression coefficient of ward care model (i.e. the central determinant) by more than 10% (regardless of statistical significance of effects). Explorative subgroup analyses per medical specialism will be conducted for each set of at least six wards with similar specialism are included. All estimates are calculated with 95% confidence intervals.

Economic analyses

Discounting of costs and effects is applied as recommended for health economic evaluations in The Netherlands [29]. A comparison is made between the intervention and control group on incremental costs and incremental effects. The incremental cost-effectiveness ratio (ICER) will be calculated as follows: ICER = (Δ costs/Δ effects) where Δ costs represents the difference in annual mean costs between intervention and control group, and Δ effects represents the difference in QALYs between the two groups.

The uncertainty associated with estimates is explored with a bootstrap resampling procedure to produce cost-effectiveness planes as well as targeted one-way sensitivity analyses of potential drivers of key cost (such as type of ward). The bootstrapped ICERs will be presented in a cost-effective acceptability curve displaying the probability that the intervention is cost-effective for a wide range of willingness-to-pay thresholds. P-value is set at 0.05 to indicate statistical significance. To test for several assumptions (i.e. cost-prices and salary), one-way sensitivity analyses will be conducted on the range of extremes.

Qualitative data analyses

The semi-structured interviews are audio-taped and transcribed verbatim with participants consent. A deductive process of thematic analysis is used to classify responses within themes. The theoretical domains previously described are used as the coding framework. Analyses are conducted in Atlas.ti software. Two researchers will code and analyze the transcript independently to reduce subjectivity. Consensus is reached by discussion. Member checking confirm the credibility of the data: each participant will be given a full transcript of the interview with a summary of themes to determine whether the themes were appropriately identified and matched their responses.

Ethical considerations

The research ethics committee of the Radboud university medical center has declared that this study doesn't fall within the remit of the Medical Research Involving Human Subjects Act (WMO) (registration number 2012/306). This means that this research can be carried out without an approval by an accredited research ethics committee. All data will be handled strictly confidential. Written informed consent is obtained from all patients.

Discussion

To our knowledge, this is the first multicenter study which investigates the efficacy and effectiveness of reallocation of hospital ward care from MDs to PAs. Most international studies on reallocation of care to PAs are restricted to primary or critical care, limited to one outcome measure, or are of insufficient methodological quality [2].

The major strengths of this study are the multicenter design and the broad view; we perform measurements both at patient, care provider and hospital ward level. A wide variation of instruments and methods is used to obtain data; we use both quantitative measurements (medical patient records, patient and care provider questionnaires, work schedules) and qualitative measurements (semi-structured interviews). As a consequence, we provide not only useful information about the objective effects of reallocation of hospital ward care on a range of outcomes, but we are also able to determine barriers and facilitators for the implementation.

One of the limitations is the non-randomized design of this study. In the Netherlands, PAs followed a so-called 'dual program', which means that students are employed within a particular medical specialty while enrolled in the master's PA program (Table 1). After graduation, PAs are intended to be employed at the same department. The suggestion of randomly relocating the graduated PA to other hospital wards would lead to resistance among the medical specialists who put considerable effort and time to training and supervision.

The non-randomized character of this study implies an increased risk for confounding, which we will take into account in the multivariable analyses. Another challenge is to deal with the heterogeneity of patients across hospital wards. Each hospital differs slightly in determinants like the organization of ward care (care by medical resident or specialist, arrangement of supervision), policies about quality of care, patient case-mix and medical subspecialties, which might reduce explained variation and subsequently reduce the power of this study. When appropriate, we will conduct explorative secondary quantitative and qualitative analyses to explain heterogeneity.

This multicenter study adds to the current body of knowledge by creating more knowledge of the effects of task reallocation in hospitals on the efficiency, quality and continuity of care. Findings from this study will help to further define the role of nonphysician clinicians and provides possible key components for the implementation of PAs in hospital ward care.

Competing interests
MW and MGH Laurant have no conflicts of interest. Both MJC Timmermans and JAH van Vught work as a teacher at one of the PA Master programs.

Authors' contributions
ML and MT are responsible for the design of the study with comments of AvV and MW. MT wrote first draft of the manuscript and all other authors revised this critically. MT is responsible for the data collection and data management with direct supervision and feedback from ML. All authors read and approved the final manuscript.

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BMC Health Services Research

ERRATUM Open Access

Erratum to: The effectiveness of substitution of hospital ward care from medical doctors to physician assistants: a study protocol

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Unfortunately, the original version of this article [1] contained an error in the text. The correction of this error and also an adjusted sample size calculation is detailed below.

Corrections

Year of authorization of PAs

After publication of our study protocol, we noticed an error at the fifth bullet on page 2 [1]. We described that since January 2013 PAs are authorized to indicate and perform predefined medical procedures and subscribe medication without supervision. January 2013 should however be January 2012 [2].

Adjusted sample size calculation

In the original study protocol we described a sample size calculation in which an average length of hospital stay (LoHS) of 7 days and a standard deviation of 6 days was used. These numbers were based on a study of Borghans et al, in which the LoHS was presented of all patients who were admitted at 69 hospitals in the Netherlands during one year [3]. This concerned all possible medical specialisms. However, we included the following specialisms in our study population: general surgery, pulmonology, gastroenterology, cardiology, orthopedics and otolaryngology (ENT). The medical specialisms with relatively high LoHS (f.e. cardiothoracic surgery, geriatrics, dermatology) and relatively low LoHS (f.e. ophthalmology, plastic surgery, gynecology) were not represented [4]. This composition prompted us to recalculate the required sample size. Instead of a LoHS of 7 days and a SD of 6, a LoHS of 6 days and a SD of 4.8 days was used, which better fitted with our study population. All other parameters remained the same. Taking into account an expected drop out of maximum 2 matched pairs, 34 wards (17 in each arm) with each 100 patients are required. In case of no drop out, 50 patients per ward are sufficient to detect a significant difference in LoHS, with an expected 20 % reduction in LoHS, alpha 5 %, power 80 % and ICC 0.06.

As a consequence of the matched controlled study design, the SD in our study population might be smaller than the above mentioned SD of 4.8, but we are unable to provide reliable estimates [5].

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The involvement of physician assistants in inpatient care in hospitals in the Netherlands: a cost-effectiveness analysis

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The involvement of physician assistants in inpatient care in hospitals in the Netherlands: a cost-effectiveness analysis

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ABSTRACT

Objective. To investigate the cost-effectiveness of substitution of inpatient care from medical doctors (MDs) to physician assistants (PAs).

Design. Cost-effectiveness analysis embedded within a multicenter matched-controlled study. The traditional model in which only MDs are employed for inpatient care (MD model) was compared with a mixed model in which besides MDs also PAs are employed (PA/MD model).

Setting: 34 hospital wards across the Netherlands

Participants. 2292 patients were followed from admission till one month after discharge. Patients receiving daycare, terminally ill patients and children were excluded.

Primary and secondary outcome measures. All direct healthcare costs from day of admission until one month after discharge. Health outcome concerned quality-adjusted life years (QALYs), which was measured with the EuroQoL-5D questionnaire.

Results. We found no significant difference for QALY gain (+0.02, 95% CI -0.01-0.05) when comparing the PA/MD model with the MD model. Total costs per patient did not significantly differ between the groups (+ € 568, 95% CI €-254-€1391, p=0.175). Regarding the costs per item, a difference of €309 per patient (95% CI €29-€588, p=0.030) was found in favor of the MD model regarding length of stay. Personnel costs per patient for the provider who is primarily responsible for medical care at the ward, was lower on the wards in the PA/MD model (€-11, 95% CI €-16- €-6, p<0.01).

Conclusions. This study suggests that the cost-effectiveness on wards managed by PAs, in collaboration with MDs, is similar to the care on wards with traditional house staffing. The involvement of PAs may reduce personnel costs, but not overall healthcare costs.

Trial registration: ClinicalTrials.gov Identifier: NCT01835444, April 2013

Key words: Professional role revision, substitution, physician assistant, hospital care, resource use, costs

Strengths and limitations of this study

- This study increases the understanding of the implications of reallocating inpatient care from MDs to PAs on total healthcare costs, as well as on resources uses.
- This study captured a large number of patients from 34 hospital wards, which cover both teaching and non-teaching hospitals and six different medical disciplines.
- The non-randomized character of this study implies an increased risk for confounding, which we accounted for in the multivariable analyses and subgroup analyses.
- Although we performed subgroup analyses, we cannot exclude that local differences like policies about quality of care and patient case-mix influence the results.

BACKGROUND

Because of an increased appreciation of continuity of care, pressure to deliver healthcare efficiently, and local shortages of medical doctors (MDs), medical care for admitted patients is increasingly reallocated to physician assistants (PAs).[1-3] A PA is a health professional licensed to practice medicine in defined domains, with variable degrees of professional autonomy.[4] PAs who provide medical care for admitted patients usually work in a team comprising both PAs and MDs (i.e. residents, medical specialists or hospitalists).

Literature suggests that PAs add to the quality of care by increasing continuity for both patients and hospital staff.[2] The turnover of house staff is traditionally high due to use of recent medical graduates who are planning to do fellowships and the mandatory rotational cycles.[5] PAs generally do not rotate and constitute a factor of stability in the continually changing medical workforce. Previous studies show that quality of care for admitted patients delivered by a PA-based team is comparable to that of a resident-based team, and that patient evaluations are at least as good.[6-10] Our own study showed similar quality and safety of care, but better patients experiences on wards with a PA-based team.[11] Estimates of PA employment on costs vary across the conducted studies.[9,10] These studies concerned one clinical discipline within one hospital, which reduces the generalizibility of findings. Besides, all studies were conducted in the United States, where most hospitals involving PAs concern only acute care. In the Netherlands, most hospitals include both acute and chronic care under one roof. Given the outcomes of these studies and their limitations, we conducted a multicenter study that included PAs providing care to hospitalized patients including a range of clinical disciplines. This paper reports on the cost-effectiveness of substitution of inpatient care from MDs to PAs. Costs concerned all direct healthcare costs from day of admission until one month after discharge. Health outcome concerned quality-adjusted life years

(QALYs), which is a composite measure of effectiveness consisting of quality of life and life years gained.

METHODS

Study design

This economic evaluation was performed alongside a multicenter non-randomized matched-controlled study, which was performed in the Netherlands. In this study, the care on hospital wards utilizing a mixed 'PA/MD model' (intervention group) was compared with the care on wards utilizing a solely 'MD model' (control group).[12,13]

MD model

In the MD model, only MDs provide medical care for admitted patients at a specific hospital department. Most of them are junior or senior residents. The resident is physically present at the department each weekday and is the first point of access to medical care during office hours (MR model). Their work includes daily clinical care and patient management. The residents are supervised by attending physicians. In some cases, especially in smaller hospitals where often no residents are employed, the medical specialists provide all medical care for the admitted patients (MS model).[13]

PA/MD model

In this model, the PAs who were employed at the wards are substitutes for the residents. Their tasks and responsibilities are largely comparable. PAs have the same authorizations as residents: they can make indications for treatment, perform predefined medical procedures and subscribe medication independently within their field of expertise.[14] We included two different models within the intervention group: a model in which PAs collaborate with

residents (mixed PA/MR model) and a model in which only PAs are the first point of access to medical care (PA model). In both models, the PAs as well as the residents were supervised by attending physicians.

Control wards were matched with the intervention wards on the basis of hospital type (i.e. academic or non-academic) and medical specialty (i.e. a range of surgical and medical specialties).No wards with general medicine were involved. Hospital wards were included in the intervention group if the PA covered at least 51% of the available ward care hours per week during dayshifts on weekdays. Wards were included in the control group if exclusively MDs provided medical care. The primary analysis had patients' length of stay as primary outcome. Further details of the study design have been described elsewhere.[12] The economic analysis was conducted from a healthcare perspective, with a time frame from admission till one month after discharge.

Study population

This study focused on the patients admitted to the hospital wards. Exclusion criteria for patients were: 1) Younger than 18 years; 2) Terminally ill; and 3) Receiving daycare. Daycare was defined as hospital admissions that were intended to last 24 hours or less (observation status).

Health outcome

The primary health outcome in this evaluation is the QALY (quality-adjusted life years). A QALY is a generic measure of disease burden.[15] QALYs were derived using the EuroQoL-5D questionnaire (EQ-5D-3L)[16], which is a widely used validated patient questionnaire comprising five domains: mobility, self-care, usual activities, pain, and anxiety/depression.

Each domain has three possible levels indicating; no problems, moderate problems or severe problems. The EQ-5D-3L was assessed at three time points: at admission, discharge and one month after discharge. We used the Dutch utility weight to calculate utilities.[17]

Cost outcomes

The primary cost outcome was the sum of direct costs associated with the principal admission and costs that occurred within one month after discharge that were potentially related to hospital admission. Resources used during admission were extracted in detail at an individual patient level from patient medical records and included laboratory tests, diagnostic tests, medication and blood products. Also the frequency and type of consultations of health care suppliers and the number of days of unplanned stay at ICU were derived from the medical records. To minimize information bias, a random sample of 10% of the patient records per ward was reassessed by a second researcher, who was blinded for the results from the initial researcher. In case of an inter-rater agreement of less than 95%, the records of the total sample were reassessed.

Personnel costs included the costs for the residents, PAs and medical specialist who were primarily employed for medical care for the admitted patients. Also the costs for supervision time by attending physicians were included. We measured the number of hours spend for medical ward care per professional by examination of work schedules. All MDs and PAs who had the primary task to provide medical care for admitted patients were asked to fill in their real work schedule during four fixed weeks: week 3, 7, 11 and 15 after the start of the inclusion of patients. Next, we divided the number of working hours by the number of patients for which they were in charge. The number of hours spent for supervision was derived from an online questionnaire. We asked each attending physician for the average

number of hours they weekly spend for supervision. These hours were added up for all attending physicians of the department, and divided by the number of patients who were admitted at the ward.

Volumes which were measured between discharge and one month afterwards included days of unplanned readmission, number of presentations at emergency departments, number of contacts with a general practitioner, and the required home care. These volumes were collected from a patient questionnaire that was sent one month after discharge. We chose for 1 month after discharge, as events happened after that period are less likely to be related to the initial admission period.[18] Costs were calculated by multiplying the volumes of healthcare use with corresponding unit prices, derived from the Dutch Manual for Costing Research.[19] All figures were related to the price level of the same year (i.e. 2014). Details of the costs applied to units of resource use are provided in supplementary table S1.

Sample size calculation

Sample size calculation was based on length of stay (LOS), which was the primary clinical outcome of the multicenter study. Results for LOS have been published elsewhere.[11] The originally published sample size calculation[12] was adjusted prior to start of data collection.[20] To detect a relative difference in LOS of 20% between the 'PA/MD model' and 'MD model', assuming an average LOS of 6 days (SD 4.9), alpha 5%, power 80% and an Intra Cluster Coefficient of 0.06 for patients in same ward, 30 wards including 100 patients each were required. Taking into account an expected drop-out of maximum 2 matched pairs, 34 wards (17 in each arm) with each 100 patients were required. In case of no drop-out, 50 patients per ward would be sufficient.

Data analysis

We used descriptive analyses with counts (and proportions) or means (with SDs) to describe baseline characteristics, effects, and costs. The a priori planned analysis was a comparison between the intervention and control group on incremental costs and incremental effects. The incremental effects were analyzed using a linear mixed model approach with the QALY score as dependent variable and group and baseline QALY as independent variables, taking clustering of patients within wards into account. If similar effects on the QALY in both groups were found, a cost-minimization approach was performed by comparing differences in costs between groups using a linear mixed model approach accounting for clustering and applying bootstrapping (200 times) to create bias-corrected 95% CIs around the coefficients of the independent variables. A total of 50–200 replications are generally adequate for estimates of standard error.[21] Multivariable models were constructed to adjust for potential confounders. We took matching into account by adding covariables for the matching variables.

Missing data were imputed via multiple imputations, which was embedded within the statistical package. To explore uncertainty around costing assumptions (i.e. cost-prices and salary), sensitivity analysis was conducted on the range of extremes. Imputation models for all cost categories and utility scores were then redone accounting for changes in the sensitivity analysis. To explore heterogeneity within the results, post-hoc subgroup analyses were performed for each submodel of medical ward care, i.e. 1) the MS model: medical specialists are in charge of all admitted patients; 2) MR model: residents or junior doctors are in charge of all admitted patients; 3) mixed PA/MR model: both residents and PAs are in charge of the admitted patients; 4) PA model: PAs are in charge of all admitted patients.[13] All analyses were

carried out with Stata 11.2 (StataCorp, College Station, TX). P-value was set at 0.05 to indicate statistical significance.

Ethical considerations

Ethical approval was received from the Research Ethics Committee of the Radboud university medical center, Nijmegen (registration number: 2012/306); the committee judged that ethical approval was not required under Dutch Law. All data were handled strictly confidential and written informed consent was obtained from all patients.

RESULTS

Between April 2013 and May 2015 we included 1,021 patients spread over 17 hospital wards in the intervention group, and 1,286 patients spread over 17 hospital wards in the control group (Figure 1). In total, 23 hospitals across the Netherlands were involved. More patients in the intervention group were acutely admitted (59% versus 44% in the control group, p<0.01). Also medical specialty, hospital type, primary diagnosis and discharge destination differed significantly between the groups (table 1).

Health outcomes

We had complete QALY data for 779 patients in the intervention group (76%) and 982 patients in the control group (76%). Utilities related to the three time points and QALYs are outlined in table 2. The EQ-5D utilities did not statistically significantly differ between the study arms at baseline and throughout the study. At discharge and one month after discharge the mean difference in EQ-5D utility was -0.01 (95% CI -0.06-0.04, p=0.634) respectively -0.04 (95% CI -0.09-0.02, p=0.178), corrected for baseline utility. Similarly, the difference in QALY gain was not statistically significant during admission nor after discharge.

Resource use and costs

Ninety-nine percent of all patient records were assessed. Item-missing varied from 2% (unplanned transfer to ICU) to 9% (use of blood products). Resource use after discharge was derived from the questionnaire which was send to the patient one month after discharge. The response rate on this questionnaire was 76% in both study arms. Resources used during the period from admission till one month after discharge are summarized in supplemental table 2.

Table 3 outlines total costs per patient and costs per item. Mean total costs per patient in the intervention group did not significantly differ from the mean costs per patient in the control group: mean difference was €568 (95% CI €-254-€1391, p=0.175). Regarding the costs per item, we found significant differences of €309 per patient (95% CI €29-€588, p=0.030) regarding LOS in favor of the MD model. Personnel costs for the PA or MD who is primarily responsible for the medical care at the ward was significantly lower on the wards in the PA/MD model: mean difference €-11 (95% CI €-16- €-6, p<0.01) per patient. Costs for supervision by the staff physicians were significantly higher in the PA/MD model: mean difference €43 (95% CI €39-€47, p<0.01). Since the MD model also incorporates wards with only medical specialists, supervision is not applicable for these wards. To rule out this distortion we performed an additional analysis in which we excluded the 4 wards with only medical specialists. This resulted in an opposite difference: costs for supervision were now significantly lower for the PA/MD model compared to the MD models: mean difference € -11 (€-16- €-6, p<0.01).

Sensitivity analyses on the range of extremes did not change these results of the total costs and costs per item substantially (data not shown, but can be provided on request).

Subgroup analyses

Results for the analyses per submodel of medical ward care are shown in table 4. Mean total costs per patient did not significantly differ among the submodels. Costs for LOS were on average 465 euro per patient (95% CI -920- -10, *P*=0.045) lower in the MS model than in the mixed PA/MR model. The other models did not significantly differ from each other. Personnel costs for the provider who is primarily responsible for the medical care at the ward was significantly highest in the MS model (mean €129 (SD €37)), and lowest in the PA model (mean €51 (SD €3)). Costs for supervision were significantly highest in the MR model (mean €178 (SD €79)) and lowest in the PA model (mean €121 (SD €59)). We also found significant differences regarding costs for blood products and required home care: these were highest in the PA model.

DISCUSSION

This study aimed to determine the cost-effectiveness of substitution of inpatient care from MDs to PAs. No significant difference between the two study arms was found on QALY and total costs. Explorative analyses showed a significant difference in costs for LOS in favor of the MD model, and significant differences regarding personnel costs in favor of the PA/MD model.

To our knowledge, this is the first multicenter study that investigated the cost implications of reallocating inpatient care from MDs to PAs. A few single-centered studies have compared costs of non-acute inpatient care delivered by a PA-based team with care delivered by a resident-based team.[9,10] These studies did not measure QALYs. Results regarding total costs were mixed. Roy et al.[9] reported that the care by the PA-based team was associated with lower total costs per patient, while Singh et al.[10] reported similar costs between the study

arms. These studies can however hardly be compared with our study, because different methods to estimate costs were used and the settings were different. In addition, most of these studies compared a hospitalist/PA model with the traditional resident-based model, while hospitalists were not part of the models we used.[13]

Our previous analysis showed increased provider continuity at the ward with the presence of a PA.[13] This study shows that this increased continuity did not cause a decrease in costs, especially because of the higher costs for LOS. Subgroup analysis showed that costs for LOS were especially higher when compared to the model in which only medical specialists were involved. Costs did not significantly differ between the PA models and the model which involves only residents (MR model). An explanation for the lower costs for LOS in the MS model might be that the medical specialists have more work experience. The PA profession is relatively new; most of them have a short time of experience compared to medical specialists.[13] Over time the clinical experience of PAs will become larger, which may lead to lower costs. Besides, we cannot exclude the possibility that the lower LOS indicates that the patients which were included in the MS model were overall less complex than the patients in the other models. Although we've adjusted for relevant confounders in the multivariable analysis, it is not possible to perfectly adjust for the complexity of the patient in non-randomized comparisons.

Personnel costs for the provider who is primarily responsible for the medical care at the ward were significantly lower on the wards with the PA/MD model when compared to the MD model. Subgroup analysis showed highest costs on the wards with only medical specialists. This can be explained by the significant higher salary. Besides, we found lower costs on wards with the PA model when compared to the model which involves only residents. Since

in the Netherlands the salary of PAs is comparable to the salary of residents (table S1), the significant difference can be explained by our finding that on the wards with the PA/MD model, less time was spend per patient (table S2). This is probably caused by the finding of our previous study that PAs spend less time on indirect inpatient care than residents do.[13] A hypothesis is that since PAs tend to work for a longer time at the hospital ward, they might be more familiar with the clinical protocols and the procedures, for example when requesting diagnostic tests and consultation of other physicians. Also the increased provider continuity might lead to more efficient care.[13]

In our initial analysis, costs for supervision were significantly higher in the PA/MD model when compared to the MD model. However, this finding was biased by the wards with only medical specialists, since supervision was not applicable for these wards. Costs for supervision were higher on the wards with the mixed PA/MR model and the MR model when compared to the PA model. An explanation might be the fact that the PAs in the PA model have more work experience than the PAs and residents in the other models.[13] An alternative hypothesis is that the difference is caused by the teaching culture of the wards. 83% of all included wards with a mixed PA/MR model and 69% of all wards with the MR model are from teaching centers, while none of the wards with the PA model are.[13] As a consequence, there might be more consultation between professionals and more emphasize on education, which could be included in the supervision hours.

This study suggests that the cost-effectiveness of inpatient care delivered by a PA-based team is comparable to that of residents-based teams. This does not confirm the findings from qualitative studies, in which medical specialists experienced an increased efficiency after employing PAs.[5,22,23] However, the effectiveness which was experienced by the interviewed

providers in our own qualitative study was based on items which were not in the scope of this quantitative research.[5] Several interviewees experienced increased effectiveness because the PA performs additional tasks which were normally the responsibility of the staff physicians or residents, like integrating newly employed doctors, performing specific (complex) medical procedures, providing education or conducting quality projects. As a consequence, staff physicians and residents can be employed more effective in for example providing outpatient care or conducting surgery. Besides, residents experience increased effectiveness because they have more time to focus on the needs for their own education.

This economic evaluation was conducted from a health care perspective. The societal perspective was not taken into account. For example, educational costs for PA students are thought to be lower than educational costs for medical students, since the vocational training programs take 2.5 and 6 years respectively. Exact costs for training PA students are however hard to determine, because Dutch PA students have already obtained a healthcare related Bachelor's degree of 4 years and have at least 2 years of clinical work experience in the healthcare domain.[24] Besides, since the PA education is a shortened form of the traditional medical education, it is thought that policy makers can respond quicker on the frequently changing demand for medical professionals within healthcare organizations. Another value from the social perspective might be that becoming a PA is an interesting opportunity for nurses and other health care providers wanting to advance their career.[25,26] As a consequence, motivated employees can be saved for the healthcare workforce.

Several strengths and limitations have to be mentioned. A strength is the multicenter design, which increases the generalizibility of our findings. We included a broad range of clinical disciplines from different types of hospitals. A limitation is the non-randomized design.

Different from other countries, the Dutch PA programs incorporate a dual work-education model, which means that students are employed within a particular medical specialty from the day of their enrollment in the master's PA program.[24,27] After graduation, the majority continue their employment at the same department. The suggestion of randomly relocating the graduated PA to another hospital ward could lead to resistance among the staff physicians who put considerable effort in the training. The non-randomized character of this study does imply an increased risk for confounding, which we accounted for in the multivariable analyses. Besides, we tried to reduce heterogeneity within our data by conducting subgroup analyses for the four models for medical ward care separately. However, we cannot exclude that there are still local differences like policies about quality of care and patient case-mix which still influence our results. Besides, the results of the subgroup analyses should be interpreted with caution because of low numbers of patients per subgroup.

Conclusion

This study suggests that the cost-effectiveness on wards managed by PAs, in collaboration with MDs, is similar to the care on wards with traditional house staffing by MDs only. The implementation of PAs may reduce personnel costs, but not overall healthcare costs.

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Competing interest

The authors declare that they have no competing interest

Data sharing statement

Data files are available from the authors on reasonable request.

Author's contributions

ML and MT are responsible for the design of the study with comments of AvV, MW, EA and GvdB. MT is responsible for the data collection and data management with direct supervision and feedback from ML. MT and EA conducted the data analyses. CvB, KvB, WB, LJ, AV and FvdW were involved in the data collection of the study. MT wrote the first draft of the manuscript and all other authors reviewed this critically. All authors read and approved the final manuscript.

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TABLES

Table 1. Baseline characteristics of patients

Baseline characteristic	PA/MD model (n=1021)	MD model (n=1286)	*P* Value
Medical specialty *n(%)*			<0.01
Surgery	601 (59%)	696 (54%)	
Gastroenterology	102 (10%)	181 (14%)	
Pulmonology	91 (9%)	107 (8%)	
Cardiology	101 (10%)	124 (10%)	
Orthopaedics	103 (10%)	100 (8%)	
ENT, head and neck oncology surgery	23 (2%)	78 (6%)	
Hospital type *n(%)*			<0.01
Teaching	552 (54%)	709 (55%)	
Academic	23 (2%)	78 (6%)	
Non-academic	529 (52%)	631 (49%)	
Non-teaching	469(46%)	577 (45%)	
Gender, male *n(%)*	524 (53%)	682 (54%)	0.47
Age, years *mean ± SD*	64 ± 16	63 ± 15	0.11
Major diagnoses *n(%)*			<0.01
Digestive system	204 (20%)	247 (19%)	
Circulatory system	158 (16%)	274 (22%)	
Neoplasms	108 (11%)	195 (15%)	
Musculoskeletal system and connective tissue	120 (12%)	119 (9%)	
Injury and poisoning	135 (13%)	80 (6%)	
Infectious and parasitic diseases	59 (6%)	81 (6%)	
Respiratory system	51 (5%)	75 (6%)	
Symptoms	61 (6%)	87 (7%)	
Charlson index for co-morbidity score *mean ± SD*	1.1 ± 1.8 (43%)	1.1 ± 1.8 (44%)	0.65
(% with score ≥1)			0.66
Highest education *n(%)*			0.15
Low	371 (38%)	422 (34%)	
Middle	380 (39%)	489 (40%)	
High	233 (24%)	328 (27%)	
Ethnicity, Dutch *n(%)*	976(99%)	1212 (98%)	0.15
Marital status *n(%)*			0.29
No partner	136 (14%)	167 (14%)	
Partner	730 (74%)	949 (77%)	
Widow	119 (12%)	125 (10%)	
Smoking status *n(%)*			0.65
No, never smoked	325 (33%)	385 (31%)	
No, but ever smoked	494 (48%)	626 (50%)	
Yes, still smoking	174 (17%)	230 (19%)	
Body Mass Index *(mean ± SD)*	27 ± 5	27 ± 5	0.79
Number of hospitalizations for same problem *n(%)*			0.20
1 hospitalization	580 (59%)	693 (56%)	
>1 hospitalization	403 (41%)	540 (44%)	
Type of admission *n(%)*			<0.01
Elective	402 (41%)	687 (56%)	
Urgent	588 (59%)	547 (44%)	
Discharge destination *n(%)*			<0.01
Home	765 (90%)	965 (92%)	
Hospital	12 (1%)	30 (3%)	

Nursing home/rehabilitation center/hospice	56 (7%)	28 (3%)
Family relative	18 (2%)	25 (2%)

Note: Numbers may not add up to the total because of missing values

520

Table 2. Utilities at admission, discharge and one month after discharge, and QALY gained

Outcome	PA/MD model (n=1,015) *mean (SD)**	MD model (n=1,277) *mean (SD)**	Difference *mean (95% CI)*	*P* Value
EQ-5D				
Baseline (admission)	0.64 (0.28)	0.68 (0.29)	-0.04 (-0.12-0.03)	0.247
Discharge	0.71 (0.22)	0.72 (0.23)	-0.01 (-0.06-0.04)	0.634
One month after discharge	0.75 (0.23)	0.78 (0.22)	-0.04 (-0.09-0.02)	0.178
QALY gain during admission	0.07 (0.25)	0.04 (0.25)	0.03 (-0.02-0.08)	0.213
QALY gain after discharge**	0.04 (0.22)	0.05 (0.21)	-0.02 (-0.07-0.02)	0.216

*Values are summary estimates obtained by multiple imputation

**Difference in QALY between 1 month after discharge and discharge, adjusted for baseline utility

Table 3. Total costs per patient and costs per item (€)

Item	PA/MD model (n=1015) *mean (SD)**	MD model (n=1277) *mean (SD)**	Difference ** *mean (95% CI)*	*P Value*
Costs associated with principal admission				
Length of stay	1780 (1811)	1421 (1210)	309 (29-588)	0.030
Non-elective transfer to ICU	333 (3267)	182 (1761)	105 (-262-473)	0.575
Resources used during admission				
Medication	344 (848)	243 (748)	99 (-9- -207)	0.073
Laboratory tests	107 (168)	99 (136)	19 (-16-44)	0.366
Diagnostic tests	163 (229)	154 (235)	-1 (-44-42)	0.970
Blood products	31 (122)	36 (117)	-12 (-37-14)	0.371
Consultation with health care suppliers				
Medical or surgical consultant	30 (93)	19 (47)	4 (-6-13)	0.437
Paramedics and specialist nurses	96 (159)	73 (121)	14 (-20- 48)	0.429
Personnel				
PA/MD who is primarily responsible for medical care	71 (29)	103 (44)	-31 (-33- -28)	< 0.01
Supervision by staff physician	156 (93)	129 (104)	43 (39- 47)	< 0.01
Exclusion of wards with staff physicians only	156 (93)	173 (77)	-11 (-16- -6)	< 0.01
Costs occurred during first month after discharge				
Presentation at emergency department	108 (182)	114 (298)	-13 (-45-20)	0.448
Non-elective readmission	456 (1333)	421 (1142)	1 (-89-92)	0.977
Contact with general practitioner	55 (73)	53 (70)	0 (-7-7)	0.923
Required home care	121 (248)	98 (214)	11 (-9-30)	0.275
Total costs	**3480 (5196)**	**2869 (3260)**	**568 (-254-1391)**	**0.175**

Abbreviations: PA = physician assistant; MD=medical doctor

*Values are summary estimates obtained by multiple imputation

**Difference in mean costs per patient in the PA/MD group minus the MD group with bootstrapped 95% CI, adjusted for medical specialty, hospital type, diagnosis, comorbidities, type of admission, discharge destination

Table 4. Costs (€) per patient per submodel of medical ward care

Item	PA/MD model (n=1015)		MD model (n=1277)		*P* Value **
	PA/MR model (n=698) *mean (SD)**	**PA model (n=317)** *mean (SD)**	**MR model (n=924)** *mean (SD)**	**MS model (n= 353)** *mean (SD)**	1= PA/MR model 2=PA model 3= MR model 4= MS model
Costs associated with principal admission					
Length of stay at the ward	1921 (1949)	1469 (1413)	1557 (1335)	1064 (675)	1 vs 4: $P = 0.045$
Non-elective transfer to ICU	468 (3935)	45 (494)	249 (2072)	17 (322)	NS
Resources use during admission					
Medication	365 (943)	297 (600)	280 (869)	130 (194)	NS
Laboratory tests	116 (167)	85 (170)	114 (149)	58 (78)	NS
Diagnostic tests	202 (253)	73 (121)	152 (249)	155 (195)	NS
Blood products	16 (89)	61 (171)	33 (130)	42 (71)	1 vs 2: $P < 0.01$ 3 vs 2: $P < 0.01$
Consultation with health care suppliers					
Medical or surgical consultant	35 (108)	18 (41)	21 (50)	11 (30)	NS
Paramedics and specialized nurses	97 (175)	94 (120)	72 (130)	73 (90)	NS
Personnel					
PA/MD who is primarily responsible for medical care	80 (31)	51 (3)	93 (42)	129 (37)	1 vs 4: $P < 0.01$ 2 vs 4: $P < 0.01$ 3 vs 4: $P < 0.01$ 1 vs 3: $P < 0.01$ 2 vs 3: $P < 0.01$ 2 vs 1: $P < 0.01$
Supervision by staff physician	173 (100)	121 (59)	178 (79)	NA	1 vs 3: $P = 0.019$ 2 vs 3: $P < 0.01$ 2 vs 1: $P < 0.01$
Costs occurred during first month after discharge					
Presentation at emergency department	112 (182)	101 (182)	125 (296)	88 (307)	NS
Non-elective readmission	455 (1176)	467 (1647)	438 (1054)	388 (13564)	NS
Contact with general practitioner	57 (75)	53 (69)	54 (72)	51 (67)	NS
Required home care	109 (222)	150 (298)	104 (229)	86 (174)	2 vs 1: $P = 0.029$ 2 vs 3: $P = 0.031$ 2 vs 4: $P = 0.025$
Total costs	3807 (5997)	2754 (2536)	3154 (3625)	2120 (1809)	NS

Abbreviations: PA = physician assistant; MR=medical resident; MS=medical specialist; NS= not significant; NA= not applicable

*Values are summary estimates obtained by multiple imputation

**Only significant p-values are noted

FIGURES

Figure 1. Flow-chart of patients

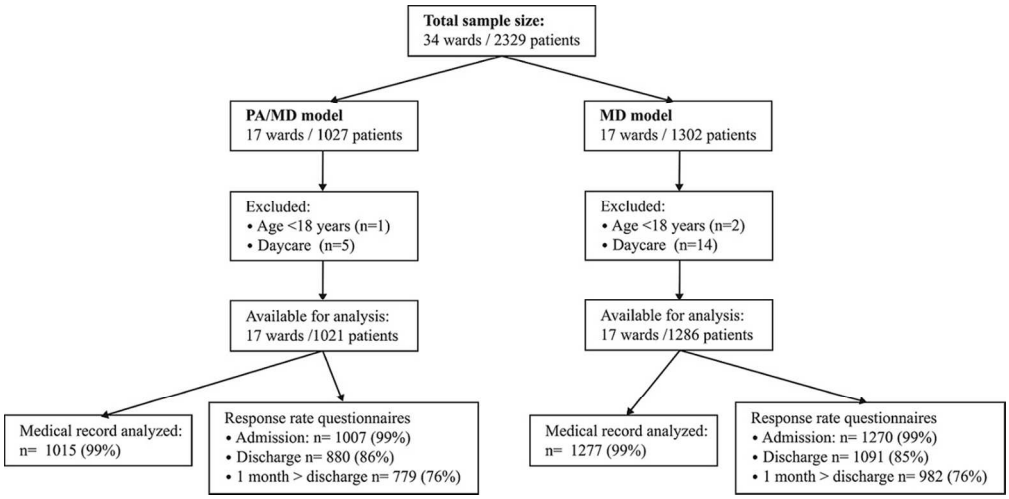

Figure 1. Flow-chart of patients

109x53mm (300 x 300 DPI)

Table S1. Details of the unit costs (year 2014) assigned to health care resource use data

Health care use	Unit cost	Unit	Details	Source
Admissions				
Ward	€210	Per day	Average price, including overhead costs, but not personnel costs and costs regarding resource use	Dutch manual for costing[1]
Intensive care unit	€2015	per day	Average price per day including all costs: personnel, resource use, overhead	Dutch manual for costing[1]
Resource use during admission				
Medication	Variable	Per unit	Minimum and maximum cost price, variable per type and dose of medicine	www.medicijnkosten.nl
Laboratory tests	€1.77	Per test	Average price per laboratory test	Dutch manual for costing[1]
Investigations. For example:	Variable	Per investigation	Variable per type of investigation	The Dutch Healthcare Authority (NZa)[2]
X-ray of the thorax	€55,81	Per x-ray	Fixed price established by the NZa	The Dutch Healthcare Authority (NZa)[2]
CT scan of the abdomen	€234,57	Per scan	Fixed price established by the NZa	The Dutch Healthcare Authority (NZa)[2]
MRI Cerebrum	€253.89	Per MRI	Fixed price established by the NZa	The Dutch Healthcare Authority (NZa)[2]
DEXA scan	€109.09	Per scan	Fixed price established by the NZa	The Dutch Healthcare Authority (NZa)[2]
Blood products				
Erytrocytes	€216	Per unit (280 ml)	Fixed price, established by Sanquin Blood Supply	Dutch manual for costing[1]
Trombocytes	€522	Per unit (330 ml)	Fixed price, established by Sanquin Blood Supply	Dutch manual for costing[1]
Plasma	€186	Per unit (310 ml)	Fixed price, established by Sanquin Blood Supply	Dutch manual for costing[1]
Consultation with health care suppliers				
Medical or surgical consultant	€27	per consult	Based on an assumed session time of 12 minutes	Dutch manual for costing[1]
Physiotherapist	€33	per consult	Based on an assumed session time of 30 minutes	Dutch manual for costing[1]
Occupation therapist	€33	per consult	Based on an assumed session time of 30 minutes	Dutch manual for costing[1]
Dietician	€27	per consult	Based on an assumed session time of 30 minutes	Dutch manual for costing[1]
Speech therapist	€30	per consult	Based on an assumed session time of 30 minutes	Dutch manual for costing[1]
Social worker	€30	per consult	Based on an assumed session time of 30 minutes	Financial department Radboud university medical center
Specialized nurse	€30,5	per consult	Based on an assumed session time of 30 minutes	Dutch manual for costing[1]
Psychologist	€64	per consult	Based on an assumed session time of 60 minutes	Dutch manual for costing[1]

Personnel				
PA/MD who is primarily responisble for medical care at the ward				
Resident	€36.24	per hour	Based on a contract of 46 hours per week (including time for education) , a salary of €4365 and 39% addition for honorarium, not including benefits and bonuses.	Dutch manual for costing[1]
Physician Assistant	€39.82	per hour	Based on a contract of 36 hours per week, a salary of €3719 and 39% addition for honorarium, not including benefits and bonuses	Dutch manual for costing[1]
Staff physician	€116	per hour	Based on an average salary, including honorariums	Dutch manual for costing[1]
Supervision by staff physician	€116	per hour	Based on an average salary, including honorariums	Dutch manual for costing[1]
Resource use during first month after discharge				
Visit to emergency department	€259	per visit	Average price per visit	Dutch manual for costing[1]
Readmission	€476	per day	Average price including all costs, independent of type of medical specialty	Dutch manual for costing[1]
Contact with GP				
GP surgery visit	€33	per consult	Based on a consult time of maximum 20 minutes	Dutch manual for costing[1]
GP home visit	€50	per consult	Based on a consult time of maximum 20 minutes	Dutch manual for costing[1]
Phoned GP for advice	€17	per consult	Based on a consult time of maximum 10 minutes	Dutch manual for costing[1]
Consult at GP cooperative	€87.41	per consult	Average price per visit	The Dutch Healthcare Authority (NZa)
Required home care				
Nursing home care	€73	per hour	Average price per hour	Dutch manual for costing[1]
Domestic home care	€23	per hour	Average price per hour	Dutch manual for costing[1]

Abbreviations: GP = General Practitioner

1. Hakkaaer- van Roijen L, Tan S, Bouwmans CAM: Handleiding voor Kostenonderzoek. Methoden en standaard kostprijzen voor economische evaluaties in de gezondheidszorg. In. Rotterdam: Health care Insurance Council; 2015
2. http://dbc-zorgproducten-tarieven.nza.nl/nzaZpTarief/ZoekfunctieDot.aspx

Table S2. Resources use during admission and one month after discharge

Item	PA/MD model (n=1015)	MD model (n=1277)
Admission		
Length of stay	6 (4-10)	5 (4-8)
Days, median (IQR)		
Non-elective transfer to ICU		
Days, median (IQR)	0 (1-2)	0 (1-1)
n/N (%)	19/987 (2%)	23/1242 (2%)
Resources use during admission		
Medication	Variable	Variable
Laboratory tests		
Number of items analyzed, median (IQR)	31 (8-66)	34 (8-71)
n/N (%)	870/954 (91%)	1130/1254 (90%)
Diagnostic investigations		
number of investigations, median (IQR)	1 (0-3)	1 (0-2)
n/N (%)	692/932 (74%)	711/1143 (62%)
Blood components		
number of blood components, median (IQR)	0 (0-0)	0 (0-0)
n/N (%)	64/998 (6%)	54/1097 (5%)
Consultation with health care suppliers during admission		
Medical or surgical consultant		
number of consultation, median (IQR)	0 (0-1)	0 (0-0)
n/N (%)	281/912 (31%)	297/1256 (24%)
Paramedics and specialist nurses		
number of consultation, median (IQR)	1 (0-4)	0 (0-2)
n/N (%)	554/953 (58%)	612/1246 (49%)
Personnel		
PA/MD who is primarily responsible for medical care at the ward	1.80 (0.93)	1.98 (1.60)
hours, mean (SD)		
Supervision by staff physician	1.34 (0.80)	1.11 (0.90)
hours, mean (SD)		
Exclusion of wards with staff physicians only	1.34 (0.80)	1.53 (0.68)
Resources use during first month after admission		
Presentation at emergency department		
number of presentations	0 (0-0)	0 (0-0)
n/N (%)	119/743 (16%)	169/941 (18%)
Non-elective readmission		
Days, median (IQR)	0 (0-0)	0 (0-0)
n/N (%)	66/738 (9%)	77/935 (8%)
Contact with general practitioner		
number of contacts	1 (0-2)	1 (0-2)
n/N (%)	214/577 (54%)	394/702 (56%)
Required nursing home care		
Hours, median (IQR)	0 (0-1)	0 (0-0)
n/N (%)	97/589 (16%)	91/713 (13%)
Required domestic home care		
Hours, median (IQR)	0 (0-0)	0 (0-0)
n/N (%)	118/741 (16%)	169/941 (18%)

CHEERS checklist—Items to include when reporting economic evaluations of health interventions

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	page 1, line 1 to 2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	page 3, line 42 to 65
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study.	page 5, line 84 to 103
		Present the study question and its relevance for health policy or practice decisions.	page 5, line 104 to 109
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	page 7, line 148 to 152; page 10, line 228 to 232;
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	page 6, line 113 to page 7, line 145
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	page 7, line 144; page 8, line 162 to page 9, line 194
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	page 6, line 118 to page 7, line 135;
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	page 7, line 145-146
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	page 9, line 193 to 196 and supplemental table 1
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	page 7, line 154 to page 8, line 161
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	page 16, line 381 to page 17, line 395
	11b	*Synthesis-based estimates*: Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	not applicable
Estimating resources and costs	13a	*Single study-based economic evaluation:*Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	

Section/item	Item No	Recommendation	Reported on page No/ line No
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	page 7, line 144; page 8, line 163 to page 9, line 196
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	Page 9, line 193-196 and supplemental table 1
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	Page 10, line 212-222
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	Page 10, line 212-229
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	Page 10, line 209-235
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Page 11, line 251 to page 12, line 283 table 1 table 2 table 3
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Page 11, line 251 to page 12, line 283 table 2 table 3 table 4
Characterising uncertainty	20a	*Single study-based economic evaluation:*Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective).	
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	Page 11, line 251 to page 12, line 283 table 2 table 3 table 4
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	Page 13, line 284-294
Discussion			

Section/item	Item No	Recommendation	Reported on page No/ line No
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	Page 13, line 297 to Page 17, line 400
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	Page 18, line 401-403
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	Page 18. Line 405-406

For consistency, the CHEERS statement checklist format is based on the format of the CONSORT statement checklist