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# Health-Economic Comparison of Paricalcitol, Calcitriol and Alfacalcidol for the Treatment of Secondary Hyperparathyroidism during Haemodialysis

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## Abstract and Introduction

**Abstract**

This study evaluated the health-economic consequences of use of intravenous paricalcitol (Zemplar®), oral calcitriol or oral and intravenous alfacalcidol for the treatment of patients with secondary hyperparathyroidism, focusing on a third-party payer perspective through inclusion of medication and hospital costs, survival rates and utilities. Cost values were based on German treatment recommendations and prices. Reference values for survival rates and utilities were based on the results of a MEDLINE search. The analysis showed a clear advantage for intravenous paricalcitol with respect to costs, effectiveness and utilities compared with treatment with oral calcitriol or intravenous alfacalcidol. Since the results were very cost sensitive with respect to selected diagnosis-related groups (DRGs) for kidney disease with dialysis, a sensitivity analysis was performed. This demonstrated first-order dominance of intravenous paricalcitol for a wide range of hospitalisation costs. In conclusion, this analysis suggested a clear benefit from the perspective of a third-party payer for intravenous paricalcitol compared with oral calcitriol and intravenous alfacalcidol in the treatment of patients with secondary hyperparathyroidism.

### 1. Introduction

Secondary hyperparathyroidism is a common consequence of chronic kidney disease, presenting in more than half of patients with end-stage renal disease.[1-3] As chronic kidney disease progresses, there is decreased capacity of the kidney to produce 1,25-dihydroxycholecalciferol (the active metabolite of vitamin D, also known as calcitriol) and to excrete phosphorus, both of which may lead to decreased serum calcium. These three factors – low serum calcium, elevated serum phosphorus and reduced levels of calcitriol – independently comprise the main causes for increased synthesis and release of parathyroid hormone (PTH) in patients with chronic kidney disease. Between 40% and 80% of patients undergoing haemodialysis have PTH levels above the recommended guideline[4] target level of 150–300 pg/mL.[5,6] Application of these data to the prevalence of haemodialysis patients in Germany[7] suggests that the prevalence of secondary hyperparathyroidism in the general population is 426 patients per million or 0.042%.

Elevated PTH levels results in excessive bone turnover, which subsequently leads to renal osteo-dystrophy.[3,8] To prevent excess bone turnover, active vitamin D, calcitriol and analogues, mainly alfacalcidol, have been used in end-stage renal disease patients undergoing dialysis in Germany. These vitamin D compounds reduce PTH synthesis[9] and increase absorption of calcium in the intestines.[10] However, these treatments have been associated with hypercalcaemia, hyperphosphataemia and elevated calcium-phosphorus product (Ca × P).[11] These adverse effects are associated with soft tissue and vascular calcification,[12-14] leading to cardiovascular disease, which is thought to be a key factor in explaining the increased (10- to 30-fold) cardiovascular mortality among patients with chronic kidney disease relative to the general population.[15] Furthermore, cardiovascular mortality is the primary cause of death in patients on dialysis.[15]

In order to minimise these undesirable effects, vitamin D analogues with less calcaemic activity have been developed. Paricalcitol is a third-generation vitamin D analogue that lacks the exocyclic carbon at position 19 and acts as a selective vitamin D receptor activator.[16,17] Pivotal randomised controlled trials with intravenous paricalcitol conducted in haemodialysis patients have demonstrated a significant decrease in serum intact PTH (iPTH), a significant reduction in serum alkaline phosphatase (suggesting improvement in bone health), and minimal impact on serum calcium, phosphorus and Ca × P product compared with placebo.[18-20] Recently, Teng et al. reported a 20% survival benefit associated with use of activated vitamin D in end-stage renal disease patients on dialysis.[21] Furthermore, studies have shown improved mortality (significantly higher survival rate) and morbidity (fewer hospitalisations per year and fewer hospital days per year) in patients in whom secondary hyperparathyroidism was treated with paricalcitol compared with those treated with calcitriol.[22,23] Additionally, patients treated with paricalcitol achieved faster rates of PTH suppression compared with calcitriol.[24]

We hypothesised that use of intravenous paricalcitol in end-stage renal disease patients with secondary hyperparathyroidism would reduce healthcare-related costs from a third-payer perspective more effectively than use of calcitriol or alfacalcidol. To date, no published cost-effectiveness studies have compared intravenous paricalcitol to calcitriol

or alfacalcidol; therefore, in an effort to determine the most cost-effective regimen for treating end-stage renal disease patients with secondary hyperparathyroidism on dialysis, we developed a cost-consequence analysis, supplemented by a cost-effectiveness analysis and a cost-utility analysis. In each of the three analyses, 1-year costs related to drug therapy and all-cause hospitalisations for paricalcitol, calcitriol and alfacalcidol therapy were compared.

## 2. Methods

A decision analysis model focusing on hospitalisation, survival rates and utilities for paricalcitol and calcitriol was used (Figure 1). Costs included yearly cost for medications and the costs associated with hospitalisation.

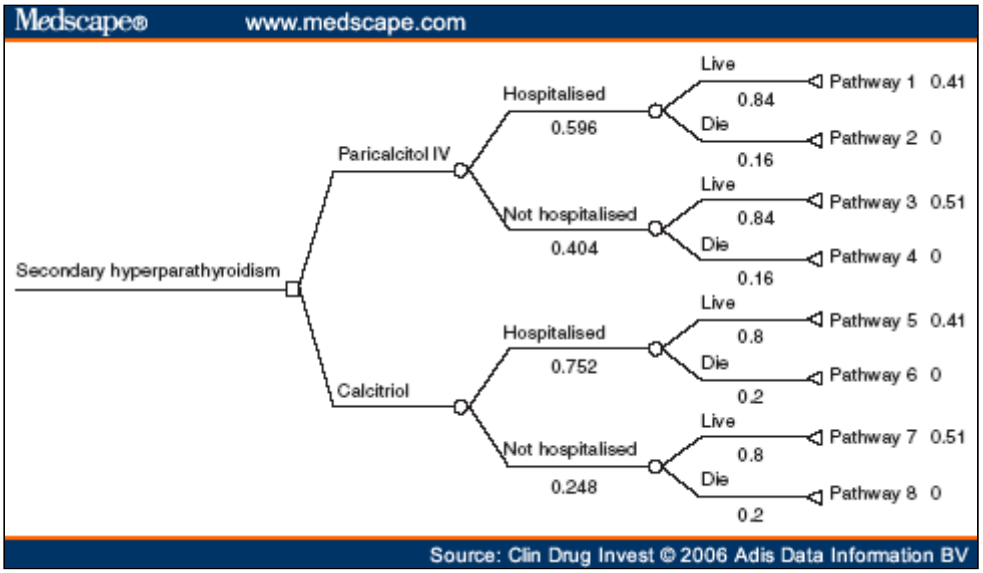


**Figure 1.**

Decision analysis model and model assumptions for treatment of secondary hyperparathyroidism. IV = intravenous.

A MEDLINE search was conducted for the period January 1960 through February 2005 (inclusive) to identify publications on the comparative incidence of hospitalisation and survival rates in patients treated with paricalcitol, calcitriol or alfacalcidol.

All costs were based on 2005 euro costs without discounting. A 1-year time period was used based on the available published literature relating to probability of outcomes.

### 2.1 Medication Cost

For calculation of the medication costs for oral alfacalcidol and calcitriol, we assumed a daily dosage of 0.5 µg/day, and an intravenous alfacalcidol dose of 1.5µg three times a week administered continuously for 1 year. Since haemodialysis is characterised as long-term treatment, pharmacy retail prices of the highest package size (N3) were used to calculate the cost of each vitamin D medication. These assumptions were based on treatment recommendations in the German pharmaceutical guidelines.[25]

The medication cost per dialysis was calculated by determining the yearly cost and then dividing it by 156 dialyses/year (three dialyses per week for 52 weeks). The costs of alfacalcidol and calcitriol for the treatment of secondary hyperparathyroidism in haemodialysis ranged from €2.35 to €3.00 per dialysis based on the administration of capsules. Since German regulations do not allow ampoules to be split for several applications or patients, intravenous alfacalcidol cost was calculated by increments of 2µg, with a cost of alfacalcidol per dialysis of €15.84 (see ).

**Table I. Medication Costs for Alfacalcidol, Calcitriol and Paricalcitol[a]**

| Medication | Package size | Cost/pack (€) | Cost/dialysis[b] (€) | Cost/day (€) | Cost/year (€) |
|---|---|---|---|---|---|
| **Alfacalcidol** | | | | | |
| Eins Alpha® capsule | 100 × 0.5µg | 103.36 | 2.41 | 1.03 | 375.95 |
| Eins Alpha® injection | 10 × 1.0mL(2 µg/mL) | 158.46 | 15.84 | 6.79 | 2478.35 |

| | | | | | |
|---|---|---|---|---|---|
| **Calcitriol** | | | | | |
| Bocatriol® capsule | 100 × 0.5µg | 104.01 | 2.43 | 1.04 | 379.60 |
| Calcitriol-Nephro® capsule | 100 × 0.5µg | 100.82 | 2.35 | 1.00 | 365.00 |
| Decostriol® capsule | 100 × 0.5µg | 104.01 | 2.43 | 1.04 | 379.60 |
| Rocaltrol® capsule | 100 × 0.5µg | 128.67 | 3.00 | 1.29 | 470.85 |
| **Intravenous paricalcitol** | | | | | |
| Zemplar® | 5 × 5µg | 127.18 | 25.44 | 10.90 | 3978.50 |

[a]Source: German Red List, January 2005.
[b]Assumes three dialysis sessions per week.

Intravenous paricalcitol (Zemplar®)[1] is administered not more than three times a week during dialysis, with initial dose depending on PTH-level (dose [µg] = iPTH [pg/mL/80]).[26] The annual paricalcitol dose was determined based on data from a double-blind, randomised, multicentre study comparing the efficacy and safety of intravenous paricalcitol and calcitriol in suppressing PTH in haemodialysis patients.[24] Since the study treatment duration was 8 months, the mean dosing at months 5 through 8 was extrapolated to months 9 through 12. The calculated mean weighted dose ratio was 3.14:1µg paricalcitol:calcitriol, over 12 months.[27] Again, since Germany does not allow ampoules to be split for multiple administrations to patients, increments of 5µg per dialysis session were used for this study. According to the German Yellow List, 5 × 5µg Zemplar® cost €127.18, which is €5.09 per µg and €25.44 per dialysis.[28]

For the calculation of medication costs per day and per year we assumed dialysis was conducted three times a week, equivalent to a ratio of 3/7.

### 2.2 Hospitalisation Costs

The number of hospitalisations was derived from the publication by Dobrez et al.[22] These authors analysed data from adult end-stage renal disease patients (n = 11443), new to haemodialysis, who started treatment with intravenous paricalcitol or intravenous calcitriol. Inpatient costs per patient per year were calculated using the total number of all-cause hospitalisations for patients who started and remained on paricalcitol or calcitriol. This approach was used instead of using days hospitalised in order to be consistent with the new diagnosis-related group (DRG)-system in Germany (G-DRG), which was introduced in 2004. In Germany, the economic value of each DRG is composed of points per indication-specific procedure multiplied by a basic hospital valuation that is expressed in euro. Three G-DRGs – L60A, L60B and L60C – were used, with a countrywide average base-case value of €2800 as shown in . We used G-DRG L60B as the base case because of the relatively high percentage of International Classification of Diseases, Revision 10 (ICD-10) N.18.0 'end stage renal disease´ entries that served as the key diagnosis.[29]

**Table II. Diagnosis-related Groups (DRGs) for Kidney Disease With Dialysis in Germany[a]**

| DRG | Description | Points | Base-case value (€) | Costs per admissioncase (€) |
|---|---|---|---|---|
| L60A | Kidney disease with dialysis – haemolytic-uraemic syndrome or complex diagnosis and extremely severe complications | 3.117 | 2800 | 8727.60 |
| L60B | Kidney disease with dialysis – not haemolytic-uraemic syndrome but complex diagnosis and extremely severe complications | 2.277 | 2800 | 6375.60 |
| L60C | Kidney disease with dialysis – not haemolytic-uraemic syndrome or complex diagnosis or extremely severe complications*or*Kidney disease without dialysis – with haemolytic-uraemic syndrome or extremely severe complications | 1.532 | 2800 | 4289.60 |

[a]Reference year for DRG values = 2005.

Calcitriol and alfacalcidol are the two main drugs used to treat secondary hyperparathyroidism during haemodialysis in Germany. Calcitriol is available only in the oral dosage form, whereas alfacalcidol is available in both intravenous and oral dosage forms. Since alfacalcidol is hydroxylated in the liver to form calcitriol following administration, this model assumes that alfacalcidol is associated with the same number of hospitalisations as calcitriol.

### 2.3 Survival Rates

Survival rates were derived from historical cohort data (n = 67399) comparing patients new to intravenous paricalcitol versus calcitriol therapy who were undergoing haemodialysis.[23] The authors reported annual survival rates at month 12 of 0.84% for paricalcitol and 0.80% for calcitriol.[23,30] These rates were used in the decision analysis model (figure 1). Again, according to the aforementioned rationale relating to the metabolism of alfacalcidol (see section 2.2), this model assumes that alfacalcidol is associated with the same survival rate as calcitriol.

### 2.4 Utilities

Utilities were based on two comprehensive tables of cost-utility ratios published between 1976 and 2001.[31] These tables include all published ratios, sorted by disease area. Utility data specifically focusing on end-stage renal disease and haemodialysis were selected ( ). On the basis of these published patient utility values, a score range between 0.61 and 0.41 was reported. No utility studies that differentiated haemodialysis patients with second-ary hyperparathyroidism from haemodialysis patients who were hospitalised were found. Typical signs and symptoms of secondary hyperparathyroidism include bone pain, fatigue and itching. Therefore, based on the range of utility scores published (0.61–0.41), a mean value of 0.51 was selected for non-hospitalised haemodialysis patients with secondary hyperparathyroidism.

**Table III. Published Utility Scores for End-stage Renal Disease and Haemodialysis**

| Health state | Score | Reference | Year of publication |
|---|---|---|---|
| End-stage renal disease | 0.59 | Lawrence et al.[32] | 1995 |
| End-stage renal disease | 0.61 | Eastman et al.[33] | 1997 |
| End-stage renal failure | 0.567 | Kiberd and Jindal[34] | 1995 |
| End-stage renal failure due to diabetes | 0.61 | Diabetes Group[35] | 1996 |
| End-stage renal failure | 0.61 | van Os et al.[36] | 2000 |
| End-stage renal failure | 0.576 | Kiberd and Jindal[37] | 1998 |
| Patients with end-stage renal disease treated with | | | |
| full-care centre haemodialysis | 0.66 | de Wit et al.[38] | 1998 |
| limited-care centre haemodialysis | 0.81 | de Wit et al.[38] | 1998 |
| Dialysis | 0.41 | Kiberd[39] | 1994 |
| Dialysis | 0.43 | Churchill et al.[40] | 1987 |
| Dialysis | 0.453 | Coffey et al.[41] | 2002 |

De Wit et al.[38] evaluated utility scores for inpatient dialysis compared with outpatient dialysis – in both cases for patients with end-stage renal disease – with an absolute score difference of 0.15. As congestive heart failure (CHF) is a common diagnosis and reason for hospitalisation in haemodialysis patients,[3] CHF utilities were used to estimate utility in the hospitalised patients. When Capomolla et al.[42] examined utility differences between hospitalised and non-hospitalised patients with CHF, they reported utility scores of 0.63 and 0.72, respectively ($p < 0.008$), representing a 0.09 decrease in utility for hospitalised patients. In another study, Glick and colleagues[43] compared hospitalisation rates and utility in heart failure patients receiving placebo and those receiving spironolactone. The placebo group had more hospital admissions and a decrease in utility of 0.13 compared with spironolactone-treated patients.

On the basis of this information, the difference between patient utilities per time-point for being hospitalised was estimated to be 0.100 for this analysis. The probability of an inpatient admission was derived from Dobrez et al.[22] These authors reported that 59.6% of patients taking paricalcitol were hospitalised compared with 75.2% of those taking calcitriol. The incremental utilities were calculated on the basis of multiplication of the reported probability of hospitalisation by the probability of death/survival and the utility scores according to hospitalisation/non-hospitalisation status.

## 3. Results

### 3.1 Cost-Consequence Analysis

The medication costs of vitamin D therapy differed with respect to the type of administration (intravenous vs oral). While treatment with capsules was associated with mean yearly costs of €375 (Eins Alpha®, Bocatriol®, Calcitriol-Nephro® and Decostriol®), intravenous treatment was associated with yearly costs of €2478 for alfacalcidol (Eins Alpha®) and €3979 for paricalcitol (Zemplar®) [see ].

**Table I. Medication Costs for Alfacalcidol, Calcitriol and Paricalcitol[a]**

| Medication | Package size | Cost/pack (€) | Cost/dialysis[b] (€) | Cost/day (€) | Cost/year (€) |
|---|---|---|---|---|---|
| **Alfacalcidol** | | | | | |
| Eins Alpha® capsule | 100 × 0.5µg | 103.36 | 2.41 | 1.03 | 375.95 |
| Eins Alpha® injection | 10 × 1.0mL(2 µg/mL) | 158.46 | 15.84 | 6.79 | 2478.35 |
| **Calcitriol** | | | | | |
| Bocatriol® capsule | 100 × 0.5µg | 104.01 | 2.43 | 1.04 | 379.60 |
| Calcitriol-Nephro® capsule | 100 × 0.5µg | 100.82 | 2.35 | 1.00 | 365.00 |
| Decostriol® capsule | 100 × 0.5µg | 104.01 | 2.43 | 1.04 | 379.60 |
| Rocaltrol® capsule | 100 × 0.5µg | 128.67 | 3.00 | 1.29 | 470.85 |
| **Intravenous paricalcitol** | | | | | |
| Zemplar® | 5 × 5µg | 127.18 | 25.44 | 10.90 | 3978.50 |

[a]Source: German Red List, January 2005.
[b]Assumes three dialysis sessions per week.

The incremental number of hospitalisation admissions per year was 0.846 fewer for patients who started and remained on intravenous paricalcitol than for patients being treated with calcitriol.[22] These fewer hospitalisations led to cost savings of €5394 associated with the use of intravenous paricalcitol versus calcitriol (0.846 fewer hospital admissions per year multiplied by €6376 per hospital admission). Overall cost savings totalled €1790–€1886 (i.e. €3979 - [€375–€471] - €5394) per year. On the basis of these calculations, use of intravenous paricalcitol compared with intravenous alfacalcidol was associated with cost savings of €3893 per year per patient treated for secondary hyperparathyroidism (i.e. €3979 - €2478 - €5394).

### 3.2 Cost-Effectiveness Analysis

The cost-effectiveness analysis was based on 1-year survival rates with paricalcitol (0.84) and calcitriol (0.80), as reported in the study by Teng et al.[23] On the basis of the medication and hospitalisation cost assumptions outlined, paricalcitol demonstrated first-order dominance over intravenous alfacalcidol, with cost savings of €3893 and 0.04 incremental life-years saved.

### 3.3 Cost-Utility Analysis

Utilities scores were calculated by multiplying the probabilities of hospitalisations, survival rates and utility associated with hospitalisation versus non-hospitalisation. Utility scores were totalled for each medicinal therapy and are presented in figure 1.

The sum of the utility scores for each treatment strategyresultedinaquality-adjustedlife-year (QALY) score of 0.378336 for paricalcitol and 0.34784 for calcitriol. Thus, intravenous paricalcitol was associated with an increase of 0.030 QALYs compared with oral calcitriol. When only medication costs were considered, the incremental costs for one additional QALY were estimated to be €118179 (€3979 - €375)/0.030496 QALYs) for intravenous paricalcitol compared with oral calcitriol. Inclusion of cost savings associated with decreased number of hospitalisations demonstrated first-order dominance of intravenous paricalcitol (compared with both oral calcitriol and intravenous alfacalcidol treatments).

### 3.4 Sensitivity Analysis

A sensitivity analysis was conducted to assess the impact of variables with the greatest uncertainty: hospitalisation costs and utilities. Hospitalisation costs were based on G-DRG L60A or G-DRG L60C (see ). Varying the hospitalisation costs between €4290 and €8728 resulted in extremes of an incremental total cost savings of €25 and €5883 with intravenous paricalcitol (see ) compared with oral calcitriol and intravenous alfacalcidol, respectively.

**Table II. Diagnosis-related Groups (DRGs) for Kidney Disease With Dialysis in Germany[a]**

| DRG | Description | Points | Base-case value (€) | Costs per admissioncase (€) |
|---|---|---|---|---|
| L60A | Kidney disease with dialysis – haemolytic-uraemic syndrome or complex diagnosis and extremely severe complications | 3.117 | 2800 | 8727.60 |
| L60B | Kidney disease with dialysis – not haemolytic-uraemic syndrome but complex diagnosis and extremely severe complications | 2.277 | 2800 | 6375.60 |
| L60C | Kidney disease with dialysis – not haemolytic-uraemic syndrome or complex diagnosis or extremely severe complications*or*Kidney disease without dialysis – with haemolytic-uraemic syndrome or extremely severe complications | 1.532 | 2800 | 4289.60 |

[a]Reference year for DRG values = 2005.

**Table IV. Sensitivity Analysis of Incremental Costs of Intravenous (IV) Paricalcitol Compared With Oral Calcitriol and IV Alfacalcidol Based on German Diagnosis-related Groups (DRG L60A[a] and L60C[a])**

| Variable | IV paricalcitol | Oral calcitriol | IV alfacalcidol |
|---|---|---|---|
| Medication costs (€) | | -3604 | -1501 |
| Hospitalisation costs L60A (€) | | +7384 | +7384 |
| Total incremental costs (€) | | +3780 | +5883 |
| Hospitalisation costs L60C (€) | | +3629 | +3629 |
| Total incremental costs (€) | | +25 | +2128 |

[a]See .

The utility score that was used in the cost-utility analysis for end-stage renal disease non-hospitalised patients with secondary hyperparathyroidism was selected on the basis of a range of published utility scores for end-stage renal disease and haemodialysis, together with the typical signs and symptoms associated with secondary hyperparathyroidism. Since we were uncertain of the actual values, a sensitivity analysis was performed by varying the utility scores used to calculate QALYs in the model from 0.41 to 0.61. The subsequent range of QALYs was 0.017 to 0.045, respectively. If both medication and hospitalisation costs were included in the model, intravenous paricalcitol remained dominant over oral calcitriol and intravenous alfacalcidol. This means that paricalcitol and hospitalisation costs were less and utilities were greater with paricalcitol compared with oral calcitriol and intravenous alfacalcidol

## 4. Discussion

This health-economic analysis investigated the cost, cost-effectiveness and cost-utility of intravenous paricalcitol compared with oral calcitriol and oral and intravenous alfacalcidol. The main finding was that intravenous paricalcitol demonstrated clear advantages with respect to costs, effectiveness and utilities compared with treatment with oral calcitriol and intravenous alfacalcidol (see ).

**Table V. Incremental Costs, Incremental Survival Rates and Incremental Utilities of Intravenous (IV) Paricalcitol Compared**

**With Oral Calcitriol and IV Alfacalcidol**

| Variable | IV paricalcitol | Oral calcitriol | IV alfacalcidol |
|---|---|---|---|
| Medication costs (€) | | -3604 | -1501 |
| Hospitalisation costs L60B[a] (€) | | +5394 | +5394 |
| Incremental total costs (€) | | +1790 | +3893 |
| Incremental 1-year survival rate | 0.04 | | |
| Incremental utilities | 0.030 | | |

[a]See .

The unit-cost data were based on German retail pharmacy prices, fixed in a tariff of charges with Germany-wide validity. The alfacalcidol products Doss® and Bondiol® and the calcitriol-product Osteotriol® were not chosen as comparators because of their primary indication for osteoporosis, which might explain the relatively high market share based on 4 million (Doss®) and 3.6 million (Bondiol®) defined daily doses (DDD) in 2003.[44]

For oral alfacalcidol and calcitriol, a constant dosage of 0.5μg per patient per day with 100% compliance and no change in initial doses was assumed. Since intravenous paricalcitol is administered during the dialysis session, compliance with this medication was not an issue. However, the effectiveness of oral calcitriol and alfacalcidol is dependent upon patient compliance, which favours the use of paricalcitol.

The sensitivity analysis showed a strong influence of the G-DRG used. Nevertheless, all suitable G-DRGs associated with secondary hyperparathyroidism resulted in cost savings with use of paricalcitol compared with calcitriol and alfacalcidol, demonstrating the robustness of the results.

Reference to a real-world database, namely 875 million single prescriptions in Germany in 2003, shows that the administration costs per day for alfacalcidol and calcitriol were even higher than those estimated by our analytical approach. Based on 2.5 million DDD of Rocaltrol® in 2003, the average daily costs for calcitriol were reported as €3.28, which is equivalent to yearly costs of €1197.[45] If this value were used for one day of treatment or one dialysis session with calcitriol, this would result in even higher benefit ratios for paricalcitol compared with calcitriol and alfacalcidol.

A limitation of this analysis is that the cost of adverse events has not been calculated. However, any additional cost beyond hospitalisations would potentially favour the use of paricalcitol, since a randomised controlled trial of calcitriol and paricalcitol showed a nearly 40% relative increase in the incidence of hypercalcaemia with calcitriol (9.2% and 6.7%, respectively) compared with paricalcitol.[3,24,45]

The number of hospitalisations per year was obtained from real-world clinical dialysis settings, including 11433 haemodialysis patients treated with paricalcitol (n = 4611) or calcitriol (n = 6832).[22] As the discharges per 100000 population for Germany are 20% higher than the corresponding rates for the US, a conservative modelling approach was used (i.e. a premium rate was not used).[46] The study by Dobrez et al.[22] did not provide any information about disease-specific hospitalisations in the monotherapy subpopulation. Since disease-specific hospitalisations were not reported, all-cause hospitalisations were used in this analysis.

The survival rates of patients treated either with paricalcitol or calcitriol were obtained from patients who received the same therapy for the duration of follow-up. The robustness of these data may offset the uncertainty resulting from missing information regarding patients´ time of entry to the study and withdrawal.

The external validity of the Teng et al.[23] study is supported by a second retrospective study of haemodialysis patients from a different dialysis facility commenced on either intravenous paricalcitol or intravenous calcitriol between 1999 and 2004. This study found the mortality rate (deaths/100 patient-years) was higher among patients receiving calcitriol than in those receiving paricalcitol, namely 19.6 (95% CI 18.2, 21.1) versus 15.3 (95% CI 13.6, 16.9), respectively (p = 0.0001).[47] In addition, an international prospective observational study of haemodialysis patients showed a significantly lower mortality rate with vitamin D therapy compared with no vitamin D.[48] This study also demonstrated that mortality with intravenous paricalcitol compared with no vitamin D was associated with the lowest mortality rate compared with oral vitamin D, intravenous calcitriol or any vitamin D versus no vitamin D, after adjusting for baseline demographics and co-morbidities,

and time-varying laboratory values. However, intravenous paricalcitol was not compared with intravenous calcitriol in this study. Furthermore, the US Renal Data System has shown an overall reduction in mortality rates in a current dialysis population, and suggested this phenomenon may be associated with increased use of paricalcitol and other changes in overall medical practice.[3]

## 5. Conclusion

This analysis suggests a clear benefit of intravenous paricalcitol with respect to costs, effectiveness and utilities compared with oral calcitriol and intravenous alfacalcidol in the treatment of patients with secondary hyperparathyroidism from the perspective of a third-party payer. Since direct comparative studies are not available, some assumptions were made in this analysis, which was based on results of historical cohort studies. Therefore, further investigation is required to verify the appropriateness of these assumptions.

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