Cost Analysis of Glaucoma Medications

NATHAN R. RYLANDER AND STEVEN D. VOLD

• PURPOSE: **To provide patients and health care providers with calculated yearly costs of topical glaucoma medications.**
• DESIGN: **Prospective, experimental, laboratory study.**
• METHODS: **Using the average wholesale price and common dosing patterns, we calculated the theoretical yearly cost of glaucoma medications.**
• RESULTS: **Calculated yearly cost ranged from $150.81 for generic timolol maleate 0.5% (Falcon Pharmaceuticals, Ltd, Fort Worth, Texas, USA) to $697.42 for Cosopt (Merck & Co, West Point, Pennsylvania, USA), and as high as $873.98 for a three-times-daily dose of Alphagan P 0.15% (Allergan, Inc, Irvine, California, USA). Among brand name β-blockers, yearly cost ranged between $203.47 for Timoptic 0.5% (Merck & Co) and $657.24 for Betoptic S (Alcon Laboratories, Fort Worth, Texas, USA). Generic β-blockers consistently were more economical than their brand-name counterparts. Yearly cost of prostaglandin analogs ranged from $427.69 for Travatan (Alcon) to $577.62 for Lumigan (Allergan). The two carbonic anhydrase inhibitors Azopt (Alcon) and Trusopt (Merck & Co), yielded similar economic profiles. Alphagan P 0.15% had yearly calculated costs of $559.08 for twice daily dosing per eye. The generic selective α_2-agonist brimonidine tartrate 0.2% (Bausch & Lomb Pharmaceuticals, Tampa, Florida, USA) costs approximately $352.89 and $529.34 per year for the respective two and three drops daily per eye regimens.**
• CONCLUSIONS: **Nonselective β-blockers remain the most inexpensive class of glaucoma medications. Bottle size may impact yearly glaucoma medication expenditures. Costs of glaucoma medications may impact decision making in the medical management of glaucoma. (Am J Ophthalmol 2008;145:106–113. © 2008 by Elsevier Inc. All rights reserved.)**

IN RECENT YEARS, THE RISING COST OF HEALTH CARE has become a major public concern. In ophthalmology, glaucoma constitutes a significant financial burden to the health care system. In the United States, therapeutic management of glaucoma costs an estimated $2.5 billion annually, with $1.9 billion in direct costs and $0.6 billion in indirect costs.[1] Adjusting for compliance estimates, glaucoma medication costs have been reported to comprise 38% to 52% of total direct costs.[2] Glaucoma financial increases parallel the elevation of pharmaceutical expenditures. Prescription drug expenditures are rising at a significantly faster rate than in other health care areas, with total sales of $251.8 billion in 2005, a 5.4% increase over 2004.[3]

Several prior studies have analyzed the economics of medically managing glaucoma. In their 1999 and 2001 retrospective studies, Vold and associates evaluated the yearly cost of glaucoma medications at a university-affiliated teaching hospital with its own health maintenance organization.[4,5] In their 1999 and 2003 prospective studies, Fiscella and associates presented daily cost estimates of the various glaucoma medications.[6,7] Using the prospective methodology used by Fiscella and associates, this study updates physicians and their patients regarding the yearly cost of treating glaucoma with topical medications.

METHODS

TEN BOTTLES OF EACH OF THE VARIOUS SIZES OF THE common brand name topical glaucoma medications were included in our study. A representative selection of the common generic glaucoma medications also was evaluated. With the exception of generic brimonidine tartrate 0.2% (Bausch & Lomb, Tampa, Florida, USA), all medications were donated by their respective manufacturers specifically for their inclusion in this economic analysis study. We evaluated each bottle for number of drops and actual volume. From these data, we calculated the average number of drops per milliliter, and using the average wholesale price (AWP)[8] and common dosing patterns of each medication, we determined the theoretical cost per year passed along to the patient.

We held each bottle at approximately 45 degrees, and then counted the number of drops obtained from the bottle. In congruence with proper medication application, enough pressure was placed on the bottle using thumb and forefinger so as to produce a single droplet of medication on the bottle tip that fell off on its own accord. After the bottle ceased to produce further drops, it was completely inverted for at least 15 seconds (30 seconds for the gel-forming solutions) so as to maximize the number of drops per bottle. Each medication was collected in a glass graduated cylinder, and the total volume was recorded. The 2.5-ml bottles were collected in a single 5.0-ml graduated cylinder marked in 0.2-ml gradations, the 5.0-ml bottles were collected in a single 10.0-ml graduated cylin-

Accepted for publication Aug 28, 2007.

From the Department of Ophthalmology, Scott and White Memorial Hospital and Clinic, The Texas A&M University System Health Science Center College of Medicine, Temple, Texas.

Inquiries to Steven D. Vold, Boozman-Hof Regional Eye Clinic, P.A., 3737 West Walnut, Rogers, AR 72756; e-mail: svold@cox.net

0002-9394/08/$34.00
doi:10.1016/j.ajo.2007.08.041

der marked in 0.2-ml gradations, and the larger samples were collected using a combination of the two graduated cylinders. In between sample collections, the cylinders were rinsed with 70% isopropyl alcohol and dried. Before starting any of the volumetric measurements, we inspected each cylinder to make sure no liquid remained. All medications were administered at room temperature.

Although the true cost of each medication will vary by distributor, the AWP was used as a nation-wide baseline of comparison. Cost per day was calculated in a similar fashion as originally performed by Fiscella and associates by dividing the AWP by the number of drops in each bottle and multiplying by the total average number of drops prescribed daily in both eyes.[6,7] Annual cost was calculated by multiplying the cost per day by 365.

We also compared the AWP used by Fiscella and associates in their 1999 and 2002 studies with the 2006 AWP used in this study to determined percentage change.[6,7] The percent change in AWP per bottle was calculated using the following formula:

$$\text{Percent change}_{2006-1999} = \left[\left(\text{AWP}_{2006} - \text{AWP}_{1999}\right)/\text{AWP}_{1999}\right] \times 100.$$

A similar formula was used to calculate the percent change in AWP between 2002 and 2006.

RESULTS

WE FOUND THAT OVERFILLING OF MEDICATION WAS A common occurrence in the tested products (Table 1). Latanoprost 2.5 ml (Xalatan; Pfizer, St Louis, Missouri, USA) and bimatoprost 2.5 ml (Lumigan; Allergan, Irvine, California, USA) had the most overfilling at 25.2% and 29.4%, respectively. Betaxolol 0.25% (Betoptic S; Alcon Laboratories, Fort Worth, Texas, USA; 2.5 ml, 5.0 ml, 10.0 ml, and 15.0 ml), brinzolamide (Azopt; Alcon Laboratories; 5.0 ml), dorzolamide (Trusopt; Merck & Co, West Point, Pennsylvania, USA; 10.0 ml), and generic carteolol 1.0% (Falcon, Fort Worth, Texas, USA; 5.0 ml) were slightly underfilled on average. In our study, Betoptic S 2.5 ml had the most underfilling, at an average of 12.0% below the stated volume.

The average number of drops per milliliter varied widely. Timoptic 0.5% XE (Merck & Co) had the fewest drops per milliliter at 21.62. Travatan (Alcon Laboratories; 5.0 ml) was found to have the most drops per milliliter at 40.86 (Table 1). Cost per year ranged widely depending on the class of medication and recommended daily dosing (Table 1). The most inexpensive brand name glaucoma medication was Timoptic 0.5% (Merck & Co, 10.0 ml), with a yearly cost of $203.47 at twice daily dosing. The most inexpensive overall medications were the generics timolol maleate 0.5% (Falcon, 15.0 ml) at $150.81 and metipranolol 0.3% (Falcon, 10.0 ml) at $151.96 for twice daily dosing.

With the exception of Betoptic S, the β-adrenergic antagonists (β-blockers) were the least expensive glaucoma medications. The costs varied widely amongst the brand name β-blockers, ranging between $203.47 (Timoptic 0.5%, 10.0 ml) and $657.24 (Betoptic S, 2.5 ml). Betoptic S was found to be two to three times as expensive as the other brand-name β-blocker products. Generic β-blockers produced by Falcon were included in our study and generally were more economical than their brand-name counterparts. The overall most inexpensive glaucoma treatment regimen occurred with the Falcon generic timolol maleate 0.5% (15.0 ml) at twice daily dosing in both eyes. Such a treatment plan has a calculated yearly cost of $150.81. The Falcon generic metipranolol 0.3% (10.0 ml) also was considerably less than the brand-name β-blockers, having a yearly cost of $151.96.

Yearly cost of the prostaglandin analog products ranged from $427.69 (Travatan, 5.0 ml) to $577.62 (Lumigan, 7.5 ml). The new product Travatan Z (Alcon Laboratories) yielded yearly costs of $519.88 and $516.41 for the 2.5- and 5.0-ml bottles, respectively. The AWP of Travatan Z was not listed in the 2006 edition of Redbook; therefore, per-bottle pricing was quoted by the manufacturer through personal correspondence as being the same as corresponding sizes of regular Travatan (Hinshaw T, written communication, November 8, 2006).

The two carbonic anhydrase inhibitors (CAI), Azopt and Trusopt, yielded similar economic profiles. The lowest cost per year within the CAI group was Azopt 15.0 ml at $342.50 for two drops daily per eye and $513.75 for a dosage of three drops daily per eye. Only one size of Trusopt was available (10.0 ml), and it was slightly more expensive than all sizes of Azopt, with respective yearly cost of $385.41 and $578.11 for two and three drops per eye per day.

The selective α_2-agonist Alphagan P 0.15% is available in three sizes, 5.0 ml, 10.0 ml, and 15.0 ml. We found that the 5.0-ml bottle was the least expensive, with yearly costs of $559.08 and $838.63 for two and three drops per day per eye treatment schemes. For treatment, the 10.0-ml bottle of Alphagan P 0.15% was the highest of the three sizes at $582.66 and $873.98 for twice and three times daily dosing per eye. The generic selective α_2-agonist brimonidine tartrate 0.2% also was tested in the same bottle sizes. The generic product was more economical than its brand-name counterpart, with the least expensive size being 10.0 ml, costing $352.89 and $529.34 per year for the respective two and three drops daily per eye regimens. Of the three brimonidine tartrate 0.2% sizes, the 15.0-ml bottle yielded the highest cost of $383.82 and $575.74 per year for the two and three drops per eye treatment plans.

Cosopt (Merck & Co), a combination of timolol 0.5% and dorzolamide 2.0%, is available in a 10.0-ml bottle. This product yielded a yearly calculated cost of $697.42.

TABLE 1. Volumetric and Economic Data for Glaucoma Medications

	Size (ml)	Volume (ml)	Overfill (%)	No. Drops/ml	Two Doses Daily = Two Drops/Day Total, No. Days/Bottle	Average Wholesale Price ($)	Cost/Yr ($)	Six Drops/Day Total, No. Days/Bottle	Cost/Yr ($)
Prostaglandins									
Lumigan	2.5	3.24 ± 0.05	29.4 ± 2.1	32.27 ± 0.45	52.20 ± 0.95	66.98	468.49 ± 8.50		
	5.0	5.29 ± 0.06	5.8 ± 1.1	32.23 ± 0.58	85.25 ± 1.69	133.94	573.67 ± 11.27		
	7.5	7.76 ± 0.05	3.5 ± 0.7	32.73 ± 0.57	127.00 ± 2.30	200.92	577.62 ± 10.41		
Travatan	2.5	2.61 ± 0.06	4.4 ± 2.3	39.25 ± 2.25	51.20 ± 2.82	66.96	478.65 ± 26.23		
	5.0	5.00 ± 0.05	0.0 ± 0.9	40.86 ± 2.02	102.15 ± 5.32	119.40	427.69 ± 22.39		
Travatan Z	2.5	2.76 ± 0.05	10.4 ± 2.1	34.10 ± 1.14	47.05 ± 1.40	66.96	519.88 ± 15.64		
	5.0	5.03 ± 0.05	0.6 ± 1.0	33.58 ± 0.83	84.45 ± 2.33	119.40	516.41 ± 14.33		
Xalatan	2.5	3.13 ± 0.07	25.2 ± 2.7	29.66 ± 1.08	46.40 ± 1.66	58.84	463.40 ± 16.97		
					Four Doses Daily = Four Drops/Day Total, No. Days/Bottle				
α_2-agonist									
Alphagan P 0.15%	5.0	5.17 ± 0.08	3.4 ± 1.6	23.35 ± 0.28	30.18 ± 0.47	46.21	559.08 ± 8.71	20.12 ± 0.31	838.63 ± 13.06
	10.0	10.37 ± 0.11	3.7 ± 1.1	22.52 ± 0.28	58.38 ± 1.01	93.16	582.66 ± 10.01	38.92 ± 0.67	873.98 ± 15.02
	15.0	15.48 ± 0.14	3.2 ± 0.9	23.09 ± 0.40	89.38 ± 1.85	139.74	570.91 ± 11.97	59.58 ± 1.23	856.36 ± 17.95
Generic									
Brimonidine 0.2%	5.0	5.15 ± 0.07	3.0 ± 1.4	24.83 ± 1.57	31.98 ± 2.24	32.65	374.44 ± 27.59	21.32 ± 1.49	561.66 ± 41.38
	10.0	10.28 ± 0.08	2.8 ± 0.8	26.28 ± 0.86	67.55 ± 2.29	65.24	352.89 ± 12.27	45.03 ± 1.53	529.34 ± 18.40
	15.0	15.51 ± 0.14	3.4 ± 1.0	24.08 ± 1.29	93.38 ± 5.15	97.92	383.82 ± 21.31	62.25 ± 3.44	575.74 ± 31.97
					Four Doses Daily = Four Drops/Day Total, No. Days/Bottle				
Carbonic anhydrase inhibitors									
Azopt	5.0	4.99 ± 0.10	−0.2 ± 2.0	29.64 ± 1.11	36.98 ± 1.62	37.80	373.76 ± 15.67	24.65 ± 1.08	560.64 ± 23.51
	10.0	10.04 ± 0.16	0.4 ± 1.6	29.49 ± 0.83	74.03 ± 2.44	75.60	373.14 ± 12.49	49.35 ± 1.62	559.70 ± 18.74
	15.0	15.21 ± 0.65	1.4 ± 4.3	31.85 ± 0.69	121.15 ± 6.64	113.40	342.50 ± 17.28	80.77 ± 4.42	513.75 ± 25.92
Trusopt	10.0	9.98 ± 0.12	−0.2 ± 1.2	23.53 ± 1.49	58.73 ± 3.99	61.75	385.41 ± 26.32	39.15 ± 2.66	578.11 ± 39.48
					Four Doses Daily = Four Drops/Day Total, No. Days/Bottle				
Combination									
Cosopt	10.0	10.65 ± 0.42	6.5 ± 4.2	22.33 ± 0.78	59.43 ± 2.74	113.33	697.42 ± 31.98		

(*Continued on next page*)

TABLE 1. *(Continued)*

					Two Doses Daily = Two Drops/Day Total, No. Days/Bottle			Four Drops/Day Total, No. Days/Bottle	Cost/Yr ($)
β-blockers									
Betoptic S	2.5	2.20 ± 0.05	−12.0 ± 1.9	23.41 ± 2.17		22.98		12.88 ± 1.23	657.24 ± 67.53
	5.0	4.88 ± 0.11	−2.4 ± 2.3	25.03 ± 1.81		45.96		30.53 ± 2.18	552.24 ± 41.75
	10.0	9.76 ± 0.11	−2.4 ± 1.1	26.34 ± 0.77		92.04		64.28 ± 1.76	523.02 ± 14.21
	15.0	14.96 ± 0.13	−0.3 ± 0.8	26.80 ± 0.36		137.88		100.23 ± 1.66	502.26 ± 8.39
Istalol 0.5%	5.0	5.21 ± 0.03	4.2 ± 0.6	32.34 ± 1.22	84.25 ± 3.25	48.38	209.89 ± 8.25		
Timoptic 0.5%	5.0	5.61 ± 0.30	12.2 ± 6.0	28.04 ± 1.45		22.10		39.40 ± 4.06	206.50 ± 19.24
	10.0	10.35 ± 0.32	3.5 ± 3.2	29.81 ± 1.18		42.88		77.15 ± 4.50	203.47 ± 11.46
Timoptic 0.5% XE	5.0	5.21 ± 0.38	4.2 ± 7.7	21.62 ± 1.02	56.25 ± 3.88	33.60	218.97 ± 15.21		
					Four Doses Daily = Four Drops/Day Total, No. Days/Bottle				
Generic β-blockers									
Betaxolol 0.5%	5.0	5.03 ± 0.05	0.6 ± 1.0	31.07 ± 0.65	39.08 ± 0.81	24.00	224.27 ± 4.67		
	10.0	10.01 ± 0.09	0.1 ± 0.9	31.70 ± 0.88	79.33 ± 2.19	46.50	214.11 ± 6.06		
	15.0	15.16 ± 0.10	1.1 ± 0.6	31.48 ± 0.66	119.30 ± 2.42	59.50	182.11 ± 3.73		
Carteolol 1.0%	5.0	4.92 ± 0.06	−1.6 ± 1.3	27.88 ± 0.82	34.30 ± 1.37	21.28	226.78 ± 9.30		
	10.0	10.03 ± 0.05	0.3 ± 0.5	27.74 ± 0.88	69.55 ± 2.23	40.10	210.64 ± 6.70		
	15.0	15.16 ± 0.11	1.1 ± 0.7	27.80 ± 0.48	105.35 ± 2.09	57.25	198.42 ± 3.96		
Levobunolol 0.5%	5.0	5.03 ± 0.05	0.6 ± 1.0	27.05 ± 1.43	34.03 ± 2.05	16.60	178.64 ± 10.35		
	10.0	10.01 ± 0.20	0.1 ± 2.0	25.71 ± 0.38	64.35 ± 1.74	32.25	183.05 ± 4.93		
	15.0	15.06 ± 0.07	0.4 ± 0.5	24.65 ± 0.78	92.80 ± 2.94	48.25	189.95 ± 6.04		
Metipranolol 0.3%	5.0	5.05 ± 0.07	1.0 ± 1.4	26.20 ± 0.64	33.08 ± 0.72	16.61	183.38 ± 3.94		
	10.0	10.18 ± 0.08	1.8 ± 0.8	25.34 ± 0.26	64.50 ± 0.80	26.85	151.96 ± 1.88		
Timolol 0.5% gel	5.0	5.00 ± 0.08	0.0 ± 1.6	27.15 ± 1.15	67.85 ± 2.03	32.20	173.36 ± 5.11		
Timolol maleate 0.5%	5.0	5.03 ± 0.05	0.6 ± 1.0	31.72 ± 1.61	39.88 ± 1.82	17.00	155.92 ± 7.55		
	10.0	10.03 ± 0.08	0.3 ± 0.8	29.59 ± 0.98	74.20 ± 2.43	32.35	159.29 ± 5.43		
	15.0	15.34 ± 0.24	2.3 ± 1.6	30.81 ± 0.99	118.20 ± 5.25	48.75	150.81 ± 6.75		

TABLE 2. Glaucoma Medication Average Wholesale Price Trends

	ml	AWP 1999	AWP 2002	AWP 2006	% Change, 1999 through 2006	% Change, 2002 through 2006
Prostaglandins						
Lumigan	2.5		53.13	66.98		26.07
	5.0		106.25	133.94		26.06
	7.5		159.38	200.92		26.06
Travatan	2.5		52.00	66.96		28.77
	5.0		119.40*	119.40		0.00†
Xalatan	2.5	45.03	53.00	58.84	30.67	11.02
α2-agonist						
Alphagan P 0.15%	5.0	25.94‡	36.28	46.21	78.14	27.37
	10.0	51.84	72.49	93.16	79.71	28.51
	15.0	77.80	108.80	139.74	79.61	28.44
Carbonic anhydrase inhibitors						
Azopt	5.0	20.38	28.44	37.80	85.48	32.91
	10.0	40.75	56.88	75.60	85.52	32.91
	15.0	61.13	85.32	113.40	85.51	32.91
Trusopt	10.0	46.60	53.91	61.75	32.51	14.54
Combination						
Cosopt	10.0	79.38	87.71	113.33	42.77	29.21
β-blockers						
Betoptic S	5.0	24.75	33.84	45.96	85.70	35.82
	10.0	46.00	63.18	92.04	100.09	45.68
	15.0	68.75	94.26	137.88	100.55	46.28
Timoptic 0.5%	5.0	19.79	22.10	22.10	11.67	0.00
	10.0	38.40	42.88	42.88	11.67	0.00
Timoptic 0.5% XE	5.0	28.88	34.33	33.60	16.34	−2.13
Generic β-blockers						
Timolol 0.5% gel	5.0	20.96	30.90	32.20	53.63	4.21
Timolol maleate 0.5%	5.0	16.58	17.00	17.00	2.53	0.00
	10.0	32.15	32.35	32.35	0.62	0.00
	15.0	48.12	48.75	48.75	1.31	0.00

AWP = average wholesale price.
*AWP for Travatan 5.0 ml in 2005 as obtained from the 2005 Redbook.
†Percent change of AWP from 2005 to 2006 for Travatan 5.0 ml.
‡Alphagan P 0.15% was not available in 1999.

The AWP of all bottles of medication included in our study that were available in 1999 and 2006 increased (Table 2). Betoptic S (10.0 ml, 15.0 ml) increased the most and doubled in price per bottle. The generic β-blocker timolol maleate 0.5% had the lowest percentage increase in AWP between 1999 and 2006 at 2.53%, 0.62%, and 1.31% for the respective 5.0-ml, 10.0-ml, and 15.0-ml sizes.

Between 2002 and 2006, most topical glaucoma medications also increased in AWP price per bottle. Betoptic S (10.0 ml, 15.0 ml) had the greatest percent increase at 45.68% and 46.28%, respectively. All sizes of Timoptic 0.5% and generic timolol maleate 0.5% had a 0% increase in AWP per bottle between 2002 and 2006. Timoptic 0.5% XE was the only medication in our study that exhibited a percent decrease in AWP between the years 2002 and 2006, with a decrease of 2.13%.

DISCUSSION

DROPS PER MILLILITER REMAINED FAIRLY CONSISTENT BEtween differing sizes of the same product. However, Travatan Z was found to have slightly fewer drops per milliliter in both the 2.5- and 5.0-ml sizes when compared with Travatan (Table 1). This in part may be because of the change in medication suspension resulting from the lack of preservative in the Travatan Z.

We found that cost per year varied widely, from $150.81 for generic Timolol 0.5%, to $697.42 for Cosopt, to as high as $873.98 for a three times daily dose of Alphagan P 0.15% (Table 3). Such a spectrum of cost for individual medications highlights the importance of considering the cost effectiveness of glaucoma medical management. Drug efficacy, tolerability, medication response, medical compli-

TABLE 3. Glaucoma Medication Yearly Cost Summary

	ml	Two Doses Daily = Two Drops/Day Total, Cost/Yr ($)	
Prostaglandins			
Lumigan	2.5	468.49	
	5.0	573.67	
	7.5	577.62	
Travatan	2.5	478.65	
	5.0	427.69	
Travatan Z	2.5	519.88	
	5.0	516.41	
Xalatan	2.5	463.40	
		Four Doses Daily = Four Drops/Day Total, Cost/Yr ($)	Six Doses Daily = Six Drops/Day Total, Cost/Yr ($)
α_2-agonist			
Alphagan P 0.15%	5.0	559.08	838.63
	10.0	582.66	873.98
	15.0	570.91	856.36
Generic α_2-agonist			
Brimonidine 0.2%	5.0	374.44	561.66
	10.0	352.89	529.34
	15.0	383.82	575.74
		Four Doses Daily = Four Drops/Day Total, Cost/Yr ($)	Six Doses Daily = Six Drops/Day Total, Cost/Yr ($)
Carbonic anhydrase inhibitors			
Azopt	5.0	373.76	560.64
	10.0	373.14	559.70
	15.0	342.50	513.75
Trusopt	10.0	385.41	578.11
		Four Doses Daily = Four Drops/Day Total, Cost/Yr ($)	
Combination			
Cosopt	10.0	697.42	
		Two Doses Daily = Two Drops/Day Total, Cost/Yr ($)	Four Doses Daily = Four Drops/Day Total, Cost/Yr ($)
β-blockers			
Betoptic S	2.5		657.24
	5.0		552.24
	10.0		523.02
	15.0		502.26
Istalol 0.5%	5.0	209.89	
Timoptic 0.5%	5.0		206.50
	10.0		203.47
Timoptic 0.5% XE	5.0	218.97	
		Four Doses Daily = Four Drops/Day Total, Cost/Yr ($)	
Generic β-blockers			
Betaxolol 0.5%	5.0	224.27	
	10.0	214.11	
	15.0	182.11	
Carteolol 1.0%	5.0	226.78	
	10.0	210.64	
	15.0	198.42	
Levobunolol 0.5%	5.0	178.64	
	10.0	183.05	
	15.0	189.95	

(*Continued on next page*)

TABLE 3. *(Continued)*

	ml	Two Doses Daily = Two Drops/Day Total, Cost/Yr ($)
		Four Doses Daily = Four Drops/Day Total, Cost/Yr ($)
Metipranolol 0.3%	5.0	183.38
	10.0	151.96
Timolol 0.5% gel	5.0	173.36
Timolol maleate 0.5%	5.0	155.92
	10.0	159.29
	15.0	150.81

ance, dosing regimens, and formulary coverage are factors that may justify a decision to prescribe a more costly medication. Although the larger bottles of medication might not have the lowest per year price, they may be desirable to the patient who pays a fixed copay per medication purchased. Prices also vary between pharmacies, so the patient is encouraged to shop around for the best price.

Inefficiencies in actual patient usage of drops exist, the most common inefficiency being wasting, or accidental administration of more than the prescribed dose. Wasting occurs for various reasons in a significant portion of the glaucoma patient population; therefore, the actual cost per day will differ from the calculated cost per day. Our results are based on a best case scenario in that none of the drops are wasted. The drug manufacturers have devised several ways to counter the effects of wasting, with the main methods including overfilling the bottles, bottle design, medication dispensing mechanisms, and administration techniques. To the authors' knowledge, there have been no major changes in bottle design since the study by Fiscella and associates was conducted in 2003.[7]

Overfilling of medication is one way to counter the effects of inefficiencies resulting from application error and provides a beneficial economic factor to the patient. Actual volume was found to differ slightly from the stated volume in every medication—almost every one of the medications was overfilled, with Xalatan 2.5 ml and Lumigan 2.5 ml having the greatest percentage of overfill. All sizes of Betoptic S, Azopt 5.0 ml, Trusopt 10.0 ml, and generic carteolol 1.0% 5.0 ml were slightly underfilled. Betoptic S has a frothy nature, which likely leads to some of the medication at the end of the bottle not being able to form a drop capable of being administered.

Several manufacturers have novel ways of dispensing their medication that decreases the amount of wasting resulting from streaming and to increase the ergonomics of droplet administration. Further studies are needed to assess the ergonomic comparison between the bottles of topical glaucoma medication.

As with other health care expenditures, medications tend to change in price from year to year, often increasing in price. All medications included in our study that were available in both 1999 and 2006 increased in AWP per bottle, and most available in both 2002 and 2006 also increased in AWP per bottle. The percent changes in AWP demonstrate only changes in per bottle pricing and do not consider updated bottle design, or other factors such as overfilling, that may lead to a more economic cost per year profile.

Fiscella and associates presented in their 2003 study the impact of AWP on the cost per day and the resulting variable cost per year of glaucoma medications. For example, in 1999, Azopt was found on average to be less expensive ($0.96/day) than both Trusopt ($1.02/day) and Cosopt ($1.12/day). In 2002, the trend reversed, with Azopt becoming more expensive ($1.33/day) when compared with Trusopt ($1.05/day) and Cosopt ($1.05/day).[7] We found Azopt to cost less per day (average cost of $0.99/day) than both Trusopt ($1.06/day) and Cosopt ($1.91/day) for a treatment regimen of two drops daily in each eye.

AWP has increased significantly from 1999 to 2002 to 2006 for the various topical glaucoma medications (Table 2), and such changes will influence directly comparative cost per day and cost per year. Increases in AWP of the various glaucoma medications contribute to the overall rising cost of health care.

Physicians consider many factors when treating patients with glaucoma. Ultimately, the goal of eye care providers is to give the best, most cost-effective care to their patients. Our study addresses the calculated cost per year passed on to the patient for single medication treatment plans and does not address issues of efficacy, tolerability, or patient safety. As newer medications and treatment schemes are introduced, future studies will be needed to update the rapidly changing economic information pertaining to the medical management of glaucoma.

THE AUTHORS INDICATE NO FINANCIAL SUPPORT. WITHIN THE PAST TWO YEARS, DR VOLD HAS PARTICIPATED IN SPEAKING

bureaus for Allergan, Alcon Laboratories, Merck & Co, and Pfizer. However, Dr Vold has never given any lectures on behalf of these companies specifically promoting any of their products. Involved in design of study (N.R.R., S.D.V.); conduct of study and collection of data (N.R.R.); analysis and interpretation of data (N.R.R., S.D.V.); and preparation and review of manuscript (N.R.R., S.D.V.).

All medications in this study, excluding brimonidine 0.2%, were donated by their respective manufacturers. Funding for the purchase of generic brimonidine 0.2% was provided by the Department of Ophthalmology, Scott and White Memorial Hospital and Clinic.

REFERENCES

1. Traverso CE, Walt JG, Kelly SP, et al. Direct costs of glaucoma and severity of the disease: a multinational long-term study of resource utilization in Europe. Br J Ophthalmol 2005;89:1245–1249.
2. Lee PP, Walt JG, Doyle JJ, et al. A multicenter, retrospective pilot study of resource use and costs associated with severity of disease in glaucoma. Arch Ophthalmol 2006;124:12–19.
3. IMS Health. Available at: http://www.imshealth.com/ims/portal/front/articleC/0,2777,6599_3665_77180090,00.html. Accessed Date: October 12, 2006.
4. Vold SD, Wiggins DA, Jackimiec J. Cost analysis of glaucoma medications. J Glaucoma 2000;9:150–153.
5. Vold SD, Riggs WL, Jackimiec J. Cost analysis of glaucoma medications: a three-year review. J Glaucoma 2002;11:354–358.
6. Fiscella RG, Geller JL, Gryz LL, Wilensky J, Viana M. Cost considerations of medical therapy for glaucoma. Am J Ophthalmol 1999;128:426–433.
7. Fiscella RG, Green A, Patuszynski DH, Wilensky J. Medical therapy cost considerations for glaucoma. Am J Ophthalmol 2003;136:18–25.
8. Murray L, editor. Red Book. Montvale, New Jersey: Thomson PDR, 2006:211–721.

AJO History of Ophthalmology Series

15th Century Prognostics

Hieronymus Brunschwig was a wound surgeon in Strasbourg, who in 1497 published the first major German text on wound surgery with colored illustrations. In the initial evaluation of patients Brunschwig directed the surgeon to establish quickly whether the wound would be fatal. Particularly with head wounds the eyes were examined for important signs. Sometimes patients were in such bad straits it was difficult to tell if they were dead or alive. If the pupils moved the patient was alive. If they were fixed then the patient was dead. For those who were still alive, he looked for other serious signs such as if the eyes tended to wander in their gaze and did not track together. If redness extended toward the eyes, this was worrisome especially when the head wound was posterior. If the eyes were themselves red and swollen, had a scorched look and feel, and became larger in size than usual, then that was an indication that the wound was mortal. If death was likely, Brunschwig advised that the patient not be taken on. The patient was not told his prognosis, but the situation was discussed frankly with his friends and family. A priest was called and the Sacraments given. The avoidance of surgical intervention was especially important if the practitioner was in a locale where he was not known.

Provided by Donald L. Blanchard, MD of the Cogan Ophthalmic History Society.