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## Pricing of multiple dosage prescription medications: An analysis of the Ontario Drug Benefit Formulary

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### ABSTRACT

*Objectives:* This paper investigates the pricing strategy (perfect flat pricing, perfect monotonic pricing, intermediate) used for multiple dosage medications listed in the Ontario Drug Benefit Formulary.

*Methods:* All multiple dosage solid medications containing a single active ingredient newly listed in the Ontario Drug Benefit Formulary between 1996 and 2005 were identified. The relationship between price and dosage was calculated using a previously developed method. *Results:* Seventy-three multiple dosage medications were introduced. Where medications were equivalent to existing ones in most cases companies followed the pricing strategy used by therapeutically equivalent drugs already in the formulary. Where there were no equivalent products companies did not adopt any particular pricing strategy. There was no difference in the way that companies priced scored tablets versus unscored tablets and capsules or in the way that they priced drugs that had objective measurements of efficacy/effectiveness, for example blood pressure, versus those that did not have these measurements.

*Conclusions:* When Monotonic pricing is used it leads to higher expenditures whereas flat pricing results in lower expenditures and offers more predictability in expenditures. Provincial governments should consider requiring flat pricing in return for formulary listing.

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### 1. Introduction

Medications are frequently available in multiple dosage forms, that is, with different amounts of the active ingredient in a single tablet or capsule. Offering multiple dosage forms accounts for variations in human physiology, helps ensure that the product is available to a wide range of potential users and increases the potential market size for the drug. When new brand-name multiple dosage drugs are initially marketed pricing strategies, or the steepness

of pricing, the companies use can range from making all of the dosages available at the same price, perfect flat pricing, to perfect monotonic pricing whereby the price is proportional to the strength of the medication, e.g., as the dosage doubles so does the price [1]. While manufacturing costs for multiple ingredient medications, biotech drugs or those in non-solid form may vary depending on the dosage, it is generally agreed that for solid forms of drugs (capsules and tablets) the marginal cost of manufacturing a different dosage is minimal [2] so that manufacturing costs do not dictate higher prices for higher dosages. In the words of one analyst, “price reflects marginal value, not marginal production cost” [2].

Public spending on prescription drugs in Canada rose by over 12% per year in the period 1997–2005 and by 2005 47% of drug expenditures were financed by the public sector [3].

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The development of measures to control drug costs is one of the nine planks in the National Pharmaceutical Strategy (NPS). According to the 2006 NPS progress report “to ensure that Canadians continue to benefit from robust public drug coverage, public dollars must be used efficiently” [4]. The introduction of new patented brand-name drugs has the second largest effect on drug sales, after the volume effect [5], and to the extent that these new brand-name drugs are sold in multiple dosages the type of pricing will impact differentially on provincial drug expenditures. Understanding how multiple dosage medications are currently priced may help provincial governments manage drug costs more effectively.

Following the methodology of Jönsson in a previous study in Sweden [1], the steepness of pricing of new brand-name drugs in Ontario was investigated in order to determine the pricing strategy that companies adopt with drugs available in multiple dosages. The pricing of the first product in a therapeutic class may determine how subsequent products in the same class are priced [6]. The primary analysis focused on how companies priced products depending on whether therapeutically equivalent products, also available in multiple dosages, were already listed in the Formulary. Specifically, there were two a priori hypotheses:

1. In classes where drugs are broadly similar in terms of effectiveness and safety, if one or more multiple dosage drugs in the class are already listed in the Ontario formulary, the price ratio of new drugs will follow the dominant price ratio in order to increase the chances of being listed.
2. If new drugs are not similar in terms of effectiveness and safety to ones already on the provincial formulary then companies will preferentially use monotonic pricing in order to increase revenue.

In addition, two secondary hypotheses were investigated:

3. Where drugs are available as scored tablets as opposed to either capsules or unscored tablets, companies will use monotonic pricing in order to avoid losing revenue due to tablet splitting.
4. Where the efficacy/effectiveness of drugs can be objectively measured, for example by measuring lipid levels or hemoglobin A1, companies will preferentially use monotonic pricing since higher prices at higher dosages can be rationalized by higher efficacy/effectiveness; where the efficacy/effectiveness of drugs cannot be objectively measured, companies will preferentially use flat pricing.

## 2. Methods

The Ontario Drug Benefit Program (ODBP) is a publicly run program that pays for drugs in the ambulatory care setting for seniors ( $\geq 65$  years of age) and those on social assistance. Drugs covered by the plan are listed in the Ontario Drug Benefit Formulary. Edition 34 of the formulary [7], effective 1 December 1994, was hand searched and a list of all brand-name drugs available in multiple

dosages was compiled. Subsequent hand searches of editions 35–39 (effective 27 May 1996 to 27 September 2005) were undertaken to determine new listings for brand-name drugs without generic competition, that were available in multiple dosages. This time period was chosen as there were no major policy changes introduced by the Patented Medicine Prices Review Board (PMPRB), the federal organization responsible for setting a maximum introductory price for new patented medications. Similarly, pricing policies at the level of the Ontario Ministry of Health were stable over the time period.

For each new listing the following items were abstracted from the relevant issue of the formulary: generic name, brand name, company marketing the medication, indication, edition of formulary, dosages and price of each dosage and presentation (capsule, tablet). In addition, it was noted whether or not there was an objective measurement of the products' efficacy/effectiveness. In some cases new dosages were subsequently introduced for drugs already available in multiple dosages. In these cases both the edition when the drug was first listed and when the new dosage(s) was listed were both recorded. Only drugs containing a single ingredient and available in solid form were included. If a drug was available in tablet form then the product identification section of the Compendium of Pharmaceuticals and Specialties [8] was used to determine if the tablet was scored or unscored.

In order to investigate whether drugs were therapeutically equivalent, the Anatomical Therapeutic Chemical (ATC) system was used to classify drugs. Drugs were put into the fourth level ATC group by searching the web site of the World Health Organization's Collaborating Centre for Drug Statistics Methodology [9]. The edition of the Ontario formulary in which the new drug was first listed was consulted to determine all of the previously listed drugs in the same fourth ATC group, i.e., all of the other drugs in the same fourth ATC group that were reimbursed by the ODBP. Decisions about whether or not the new drug was equivalent to existing ones in the same fourth ATC group were made using three sources of information: Australian Medicines Handbook [10], Medical Letter ([www.medletter.com/](http://www.medletter.com/)) and Therapeutic Choices [11]. These three sources were chosen because they originate in different countries (Australia, United States and Canada) and are well recognized as objective, independent sources of information. Equivalence was defined as having the same safety profile and effectiveness.

Following the methodology of Jönsson [1] the steepness of pricing was calculated as follows: the difference in price between the highest and lowest strength, divided by the difference in strength and then divided by the price per milligram for the lowest strength. In this measure, the ratio is normalized to the lowest strength, so that the ratio is 1 at perfect monotonic pricing and 0 for perfect flat pricing.

In order to test the various hypotheses three categories of price ratios were used: 0–0.33, 0.34–0.66, 0.67–1.00. Price ratios were divided into thirds to ensure adequate numbers in each category. Using quartiles or quintiles to determine the dominant price ratio resulted in the reclassification of a single drug out of the dominant price ratio category. For all other hypotheses the results of the statis-

**Table 1**  
Edition of formulary and number of new multiple dosage products listed.

Edition of formulary	Date formulary effective	Number of new listings for multiple dosage products	Number of dosages				
			2	3	4	5	6
35	27 May 1996	22	14	4	3 <sup>a</sup>	0	1 <sup>b</sup>
36	31 December 1998	22	11	9	0	2	0
37	7 March 2001	13	8	2	3	0	0
38	30 January 2003	6	4	2	0	0	0
39	27 September 2005	10	9	1	0	0	0
Total		73	46	18	6	2	1

<sup>a</sup> One product had three dosages listed in edition 35 and a fourth dosage listed in edition 36.

<sup>b</sup> Four dosages listed initially in edition 35 and two subsequent dosages listed in edition 37.

tical analyses remained the same and only dividing price ratios into thirds is reported.

For purposes of determining the dominant price ratio, in order to examine hypothesis 1, the ratios of previously listed therapeutically equivalent drugs were put into one of the three price ratio categories. The category containing the most drugs was considered to be the dominant price ratio. If the ratio for the new medication was in the dominant category it was considered to have followed the dominant price ratio. The number of new products adopting the dominant price ratio was compared to the number that did not.

For hypothesis 2, products that did not have therapeutic equivalents already listed in the Formulary were put into one of three price ratio categories. In the absence of a particular pricing strategy the number of products in each category should be expected to be the same. The actual distribution of price ratios was compared to the expected distribution using a  $\chi^2$  analysis.

To investigate hypothesis three unscored tablets and capsules were combined into a single group and the distribution of price ratios in this combined group in the previously described three price ratio categories was compared to the distribution for unscored tablets using a  $\chi^2$  analysis. The results did not change substantially regardless of whether the single medication that was scored in two dosages and unscored in one was assigned to the unscored tablet and capsules group or the scored tablet group and therefore only results assigning the medication to the scored group are reported.

To test the fourth hypothesis, drugs were divided into two groups, those where the efficacy/effectiveness could be objectively measured, for example, antihypertensives with blood pressure or oral hypoglycemics with hemoglobin A1C and those where the efficacy/effectiveness had no objective measure, for example antibiotics or nonsteroidal anti-inflammatories. Price ratios for drugs in each group were put into the appropriate price ratio category and the distributions were compared using a  $\chi^2$  analysis.

Statistical analysis was done using InStat 3 for Macintosh (Graphpad Software Inc.)

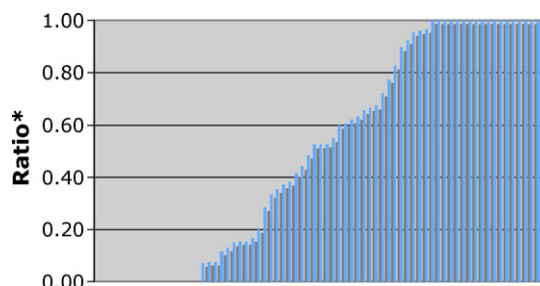
### 3. Results

Over the time period examined there were 73 new brand-name medications listed in the Ontario formulary that were available in multiple dosages. (The full list of drugs along with their generic and brand-names, indica-

tions, edition of the formulary and price ratio is available in the [web appendix](#).) Twenty-two were first listed in edition 35, 22 in edition 36, 13 in edition 37, 6 in edition 38 and 10 in edition 39. One that was initially listed in edition 35 had an additional dosage added in edition 36 and a second that was also initially listed in edition 35 had two additional dosages added in edition 37. The majority of the medications were available in 2 dosages (46) with 18, 6, 2 and 1 available in 3, 4, 5 and 6 dosages, respectively (Table 1). Twenty-two medications were in capsule form, 35 were unscored tablets, 14 were scored tablets and 1 was scored in the 2 lower dosages but not in the highest dosage.

Fig. 1 shows the price ratios for the 73 individual drugs. Seventeen had perfect flat pricing (ratio = 0) and an almost similar number (19) had perfect monotonic pricing (ratio = 1). The ratios of the other 37 ranged from 0.07 to 0.97.

There were 20 medications that were equivalent in safety and effectiveness to one or more multiple dosage drugs already listed in the formulary. Table 2 shows that the dominant price ratio used by existing drugs in the same ATC group was used by 13 of the new medications, in 5 it was not used and for 2 drugs there was no dominant price ratio as defined in Section 2. In two of the five cases where the new drug did not follow the dominant price strategy, the ratio was lower and in three it was higher. (If ratios were grouped by quartiles or quintiles 12 new medications were in the dominant price ratio, 3 were below and 3 were above.) There were seven instances where all of the existing medications in the fourth ATC class in the formulary used perfect flat pricing (ratio = 0) and six of those seven times the new medication also adopted perfect flat pricing.



**Fig. 1.** Steepness of pricing of individual products. \*Ratio = ((price of highest strength – price of lowest strength)/(highest strength in mg – lowest strength in mg))/((price of lowest strength)/lowest strength in mg).

**Table 2**  
Price ratio of new drugs compared to ratios of equivalent drugs in same ATC<sup>a</sup> group.

Drug	Price ratio	Equivalent drugs in ATC group	Price ratio of equivalent drugs	Dominant price ratio <sup>b</sup>	Price ratio of new product similar to dominant price ratio (yes/no)
Atorvastatin	0.11	Simvastatin, pravastatin, fluvastatin, lovastatin	0.10, 0.14, 0.40, 0.84	0–0.33	Yes
Bisoprolol	0.66	Carvedilol, metoprolol	0, 0.81	No dominant ratio	Not applicable
Candesartan	0	Irbesartan, losartan, valsartan	0, 0, 0	0–0.33	Yes
Carvedilol	0	Metoprolol	0.81	0.67–1	No
Cefprozil	0.96	Cefaclor, cefuroxime	0.96, 0.98	0.67–1	Yes
Cerivastatin	0.42	Simvastatin, atorvastatin, pravastatin, fluvastatin, lovastatin	0.10, 0.11, 0.14, 0.40, 0.84	0–0.33	No
Citalopram	0	Paroxetine, sertraline, fluvoxamine	0.13, 0.40, 0.80	No dominant ratio	Not applicable
Dolasetron	1	Ondansetron,	0.53	0.34–0.66	No
Eprosartan	1	Candesartan, irbesartan, losartan, telmisartan, valsartan	0, 0, 0, 0, 0	0–0.33	No
Galantamine	0	Donepezil, rivastigmine	0, 0	0–0.33	Yes
Indapamide	0.07	Metolazone	0.28	0–0.33	Yes
Irbesartan	0	Losartan, valsartan	0, 0	0–0.33	Yes
Nabilone	1	Dronabinol	1	0.67–1	Yes
Risedronate	0.72	Aledronate	0.67	0.67–1	Yes
Rivastigmine	0	Donepezil	0	0–0.33	Yes
Rofecoxib	0	Celecoxib	1	0.67–1	No
Rosuvastatin	0.15	Simvastatin, atorvastatin, pravastatin, fluvastatin, lovastatin	0.10, 0.11, 0.14, 0.40, 0.84	0–0.33	Yes
Telmisartan	0	Candesartan, irbesartan, losartan, valsartan	0, 0, 0, 0	0–0.33	Yes
Trandolapril	0.15	Quinapril, ramipril, cilazapril, enalapril, benazepril, lisinopril, fosinopril, perindopril, captopril	0, 0.07, 0.08, 0.10, 0.12, 0.15, 0.20, 0.25, 0.56	0–0.33	Yes
Valsartan	0	Losartan	0	0–0.33	Yes

<sup>a</sup> ATC is anatomical, therapeutic, chemical.  
<sup>b</sup> See text for definition of “dominant price ratio”.

For the 53 cases where there were no equivalent medications already listed in the formulary 16 had price ratios between 0 and 0.33, 13 had ratios between 0.34 and 0.66 and 24 had ratios between 0.67 and 1.00. There was no statistical difference in the actual versus expected distribution of products among the three categories ( $p = 0.3466$ , data not shown). Out of the 53 drugs, 8 used perfect flat pricing and 16 used perfect monotonic pricing.

Table 3 shows the distribution of price ratios for unscored tablets and capsules versus scored tablets. There was no significant difference between the two groups ( $p = 0.6867$ ).

There was no significant difference in the distribution of price ratios between drugs where there was an objective measure of efficacy/effectiveness and those where there was no objective measure ( $p = 0.4538$ , Table 4).

**Table 3**  
Distribution of price ratios – unscored tablets and capsules versus scored tablets.

Formulation	Price ratio		
	0–0.33	0.34–0.66	0.67–1
Capsules and unscored tablets (no. of drugs)	24	10	24
Scored tablets (no. of drugs)	6	4	5

$\chi^2: p = 0.6867$ .

**Table 4**  
Distribution of price ratios – drugs where there was an objective measure of efficacy/effectiveness versus those where there was no objective measure.

Objective measure of efficacy/effectiveness	Price ratio		
	0–0.33	0.34–0.66	0.67–1
Yes (no. of drugs)	12	4	8
No (no. of drugs)	17	11	21

$\chi^2: p = 0.4538$ .

#### 4. Discussion

When new multiple dosage drugs are listed in the Ontario formulary slightly under 25% of the time (17/73) the companies adopt perfect flat pricing, and slightly more than 25% of the time (19/73) they adopt perfect monotonic pricing. For the other 50% of medications the price ratios are distributed between the two extremes.

The first a priori hypothesis was that when new drugs are introduced that are equivalent to existing drugs in the formulary that companies would follow the pricing strategy adopted by the existing drugs and the data generally supports this hypothesis. Thirteen out of 18 new drugs used the dominant price strategy. Specifically, when the existing drugs used perfect flat pricing six out of seven times the new drugs did likewise. It appears that companies gener-

ally believe that if an equivalent product uses flat pricing they must adopt a similar strategy or face the prospect of having more difficulty getting their new product in the formulary. Using the same logic, it might also be expected that when companies did not follow the existing dominant price strategy they would tend towards flat pricing, again in an attempt to increase the likelihood of getting their drug listed. However, in this situation only two of five new drugs had price ratios that were below the dominant ratio. Using a higher or lower price ratio may be a reflection that the trade-off between the chances of getting listed and the hoped-for economic return varies by drug.

When there are no equivalent medications in the formulary companies do not appear to preferentially adopt any particular pricing strategy. However, they are twice as likely to use perfect monotonic pricing (16 products) compared to perfect flat pricing (8 products) suggesting that in some cases they may be trying to maximize revenues.

Although flat pricing might increase the chances of getting listed, it may also decrease the economic return to a company when tablets are scored since doctors could prescribe a higher dosage than is medically necessary and ask pharmacists (or patients) to split the tablet. Furthermore, in a significant number of cases the initially approved starting dosage needs to be lowered for safety reasons [12]. In this situation if a drug is priced using flat pricing then once again tablet splitting could be employed and the company would suffer economically. Hence, the third a priori hypothesis was that drugs in a scored tablet formulation would be expected to use monotonic pricing more often compared to drugs available as either capsules or unscored tablets.

Comparing the distribution of price ratios of unscored tablets and capsules versus scored tablets shows that there is no difference leading to the conclusion that the possibility of tablet splitting does not seem to be a significant factor in determining the steepness of pricing for drugs available as scored tablets. Therefore the third hypothesis is rejected. A recent systematic review has shown that doctors are generally ignorant both about the relative and absolute prices of medications [13]. Companies making scored tablets may feel that they do need to use monotonic pricing since doctors will not recognize the cost savings from splitting tablets. Alternatively, tablet splitting may be uncommon in Ontario and therefore companies are not worried about this occurrence when they set their prices. There is no available information on tablet splitting to either confirm or reject this speculation.

Finally, whether or not there was an objective measure of a product's efficacy/effectiveness made no difference in the pricing strategy adopted. It seems that companies do not try and justify monotonic pricing by claiming increased efficacy/effectiveness for higher doses.

The results of this study only apply to drugs with a single active ingredient that are produced in solid dosage forms and that are listed in the Ontario formulary. It is possible that not all dosages are listed in the formulary. In these cases, the price ratios may differ from the ones that were calculated. Pricing strategies for other medications, for example, those with multiple active ingredients and those in other formulations, may be different. Although this study

used Ontario prices its conclusions are likely to apply to the prices of multiple dosage medications in other Canadian provinces as previous research has concluded that prices of patented drugs are virtually identical in all provincial markets [14].

Olanzapine, one of the drugs with perfect monotonic pricing, cost the Ontario Drug Benefit Program \$79 million in 2005–2006 and amlodipine with a price ratio of 0.48 generated spending of \$107 million over that same period [15]. Switching to flat pricing for these two medications alone could result in substantial savings.

## 5. Conclusion

To the extent that companies use monotonic pricing over flat pricing they increase expenditures by provincial governments. Flat pricing offers public drug plans more predictability in expenditures since regardless of the dosage that is prescribed spending is the same.

The PMPRB can take the costs of making and marketing medications into consideration in determining whether drugs are excessively priced in Canada [16]. However this factor only comes into play if such a determination cannot be made after examining the price of the same medication in countries other than Canada and the Canadian prices of other medicines in the same therapeutic class. There would have to be an amendment to the Patent Act in order for the PMPRB to be able to primarily consider manufacturing costs. At present, the main option for achieving the savings that come from flat pricing would be for provincial governments to make it a requirement when companies apply to list new multiple dosage drugs in provincial formularies.

## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.healthpol.2008.12.002.

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