The Magnitude and Cost of Global Blindness: An Increasing Problem That Can Be Alleviated

KEVIN D. FRICK, PHD, AND ALLEN FOSTER, FRCS, FRCOPHTH

• PURPOSE: **To identify the potential effect on global economic productivity of successful interventions, that are planned as part of the "VISION 2020—right to sight" initiative. The initiative aims to eliminate avoidable blindness.**

• DESIGN: **This study used economic and epidemiologic modeling.**

• METHODS: **Existing data and assumptions about blindness prevalence, national populations, gross domestic product (GDP) per capita, labor force participation, and unemployment rates were used to project the economic productivity loss associated with unaccommodated blindness.**

• RESULTS: **Without extra interventions, the global number of blind individuals would increase from 44 million in the year 2000 to 76 million in 2020. A successful VISION 2020 initiative would result in only 24 million blind in 2020 and lead to 429 million blind person-years avoided. A conservative estimate of the economic gain is $102 billion.**

• CONCLUSIONS: **The VISION 2020 initiative has the potential to increase global economic productivity. (Am J Ophthalmol 2003;135:471–476. © 2003 by Elsevier Science Inc. All rights reserved.)**

BETWEEN 1975 AND 1995 THE WORLD HEALTH ORGANIzation (WHO) reported an increase in the number of cases of blindness around the world from 28 to 45 million (current estimates can be found at http://www.who.int/pbd/pbl/pbl_home.htm).[1] Demographic projections suggest that the world will become an older and more populated place over the next 20 years.[2] If current age-specific blindness prevalence rates were to persist, the combination of population growth and increased longevity would lead to a rapid increase in the global number of cases of blindness. This could have serious economic consequences.

The WHO, in partnership with the International Agency for the Prevention of Blindness launched the "VISION 2020—right to sight" initiative in 1999. The goal is the elimination of avoidable blindness due to five diseases: cataract, trachoma, onchocerciasis, vitamin A deficiency, and refractive errors. Cataract and refractive errors occur in all populations and have cost-effective sight-restoring interventions. Indeed, cataract surgery has been identified by the World Bank as one of the "most highly cost-effective" interventions that can be offered in the developing world.[3]

Trachoma, onchocerciasis, and vitamin A deficiency are focal diseases occurring in poor communities. Effective low-cost preventive measures are also available for these conditions.[4] Thus, with sufficient resources, interventions could be implemented to eliminate blindness due to these five diseases. The prevalence of blindness in developing countries could be reduced to levels similar to those in established market economies.

Previously, Smith and Smith estimated that the annual worldwide productivity cost of blindness was $168 billion using 1993 data on prevalence rates, gross domestic products, and populations.[5] These authors assumed that all adults and children were productive and that all blind individuals were completely unproductive. The projected cost could be decreased either by limiting the prevalence of blindness or by decreasing the impact of blindness on productivity through workplace accommodations and ending any discrimination that occurs against blind individuals in the workplace. The "VISION 2020—right to sight" goals focus on limiting the prevalence of blindness.

This study updated and refined the earlier work to help policymakers interpret the impact of unaccommodated blindness on the world's economy. Trends were projected in the prevalence of blindness from 2000 to 2020 with the effects of a successful VISION 2020 initiative and without

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From the Johns Hopkins Bloomberg School of Public Health, Department of Health Policy and Management, Baltimore, Maryland (K.F.); London School of Hygiene and Tropical Medicine, London, England, (A.F.).

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Inquiries to Kevin D. Frick, PhD, Johns Hopkins Bloomberg School of Public Health, Department of Health Policy and Management, 624 North Broadway, Room 606, Baltimore, MD 21205-1901; fax: (410) 955-0470; e-mail: kfrick@jhsph.edu

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TABLE 1. Population Estimates by World Development Region (WDR)

WDR Region	2000				2010				2020			
	Pop. Mills.	% 0–14	% 15–64	% 65+	Pop. Mills.	% 0–14	% 15–64	% 65+	Pop. Mills.	% 0–14	% 15–64	% 65+
China	1,262	25	68	7	1,359	21	71	8	1,434	19	70	12
Established market economies	850	18	67	15	888	17	66	17	914	16	64	20
Former socialist economies	325	18	69	13	327	16	71	14	320	16	67	17
India	1,014	34	62	5	1,168	29	66	5	1,312	26	67	7
Latin America/Caribbean	520	32	63	5	586	27	66	7	645	24	67	9
Mid-Eastern Crescent	622	37	59	4	742	32	64	5	868	29	65	6
Other Asia/Islands	818	31	64	5	939	28	66	6	1,046	24	68	8
Sub-Saharan Africa	659	44	53	3	814	42	55	3	978	40	57	3
Global	6,080	30	63	7	6,823	27	66	8	7,517	25	66	9

WDR = World Development Region.

it. Two conservative estimates of the economic productivity loss associated with unaccommodated blindness and low vision are presented with the VISION 2020 initiative and without it.

DESIGN

WE SYNTHESIZED AVAILABLE DATA USING ECONOMIC AND epidemiologic modeling. We estimated the number of blind individuals globally and the associated economic productivity loss from the year 2000 to 2020. National population figures were combined with previously published regional prevalence figures. Assumptions about the economic impact of unaccommodated blindness were made to arrive at conservative estimates of the impact of blindness and the potential effects of the VISION 2020 initiative on this impact.

METHODS

WE USED DATA FROM SEVERAL SOURCES TO PROJECT THE number of persons with blindness and the potential economic productivity costs of this blindness when unaccommodated. The following explains the processes of estimating the number of blind individuals without further interventions, estimating the associated economic productivity losses, and estimating the impact of the VISION 2020 program.

Thylefors and associates provided estimates of the prevalence of blindness in each of the eight World Development Report (WDR) regions (see Table 1).[6] The same study also provided information on the prevalence of blindness at different ages and the ratio (2.9:1) of cases of low vision (less than 6/18–3/60 in the better eye) to blindness (less than 3/60 in the better eye).[6] We assumed that the prevalence figures and ratios were applicable in the year 2000.

To project the number of cases of blindness in each country in the year 2000, we obtained the US Census Bureau projections of the number of individuals in 5-year age intervals for each country in the year 2000 (http://www.census.gov/ipc/www/idbacc.html). We calculated the prevalence for each 5-year age interval based on age-specific prevalence data from Thylefors and associates. Our calculations were based on five assumptions: (1) the prevalence for each WDR region applied to each country within the region; (2) the ratios among the prevalence rates for age intervals presented by Thylefors and associates[6] applied in each country; (3) the prevalence increased from each 5-year age interval to the next; (4) the prevalence increased linearly within each age interval 0 to 14, 15 to 44, 45 to 59, 60+; and (5) the prevalence increased at a faster rate in older age ranges than in younger age ranges. We then assumed that without further intervention the 5-year age interval prevalence rates would apply through the year 2020. We multiplied the 5-year age interval prevalence figures by the 5-year age interval populations in each country through the year 2020 (also obtained from the U.S. Census Bureau web site mentioned above) to calculate the estimated number of cases of blindness in each country in each year.

We used the gross domestic product (GDP) per capita figures provided by the World Bank to calculate the productivity loss associated with each case of unaccommodated blindness,[7] First, we converted the GDP per capita figures to year 2000 United States dollars. In countries with missing GDP per capita figures, we used the median figure in the WDR region.

We made a series of assumptions that led to a conservative estimate of personal productivity loss associated with unaccommodated blindness in the year 2000. First, we assumed that only working individuals would produce goods and services valued at the GDP per capita. We calculated the number of working individuals by multiplying the labor force participation rate and the unemployment rate by the population aged 15 to 64 years. When either rate was missing, the

TABLE 2. Estimated Prevalence of Blindness by World Development Region With and Without the VISION 2020 Initiative

WDR Region	2000	2010		2020	
		Without VISION 2020	With VISION 2020	Without VISION 2020	With VISION 2020
China	0.60%	0.74%	0.51%	0.95%	0.33%
Established market economies	0.30%	0.34%	0.32%	0.38%	0.28%
Former socialist economies	0.30%	0.34%	0.32%	0.37%	0.27%
India	1.00%	1.15%	0.80%	1.37%	0.33%
Latin America/Caribbean	0.50%	0.60%	0.50%	0.74%	0.28%
Mid-Eastern Crescent	0.70%	0.79%	0.62%	0.94%	0.33%
Other Asia/Islands	0.80%	0.96%	0.63%	1.19%	0.35%
Sub-Saharan Africa	1.40%	1.43%	0.83%	1.50%	0.38%
Global	0.72%	0.85%	0.59%	1.01%	0.33%

WDR = World Development Region.

median applicable rate in the WDR region was used. To project the productivity in the future, we assumed that the real GDP per capita grew at 3% per year. This is an optimistic assumption in some regions of the world given the recent World Development Indicators.[7]

The proportion of productivity lost was assumed to be equal to the disability-adjusted life year (DALY) weight for blindness (0.600) or low vision (0.245).[8] The original DALY weights were calculated using the definition of disability at the time: "Any restriction or lack of ability to perform an activity in the manner or within the range considered normal for a human being."[8] Social context was not included, because this would then be a measure of handicap.[8] Whereas the relationship between the disability weight and productivity may not be linear, the use of this figure led to a conservative estimate of productivity loss associated with blindness. The assumed productivity loss is lower than in other analyses. Smith and Smith assumed 100% productivity loss for blindness.[5] Shamanna and associates assumed that only 20% of those who are blind are productive and that these individuals are only 25% productive.[9] Shamanna and associates also assumed that those aged 65 and older were one half as productive as younger adults and that each blind person required 10% of a sighted adult's time for informal care. Shamanna and associates' assumptions about informal care and the economic productivity of individuals older than age 65 were incorporated into a secondary analysis in the present paper. The assumption about informal care was not unreasonable as Javitt and associates studied a random sample of 100 Indian persons who had lost their sight from cataract and determined that not only were all of them disabled, but in a substantial number of cases, a secondary family member was removed from the work force to care for the blind individual.[3] Thus, the productivity loss we estimated was deliberately conservative by nature.

To calculate the potential effects of the VISION 2020 initiative, we assumed that the prevalence of blindness would gradually decrease throughout the world to levels near those in the established market economies and former socialist economies in the year 2000. The decrease was assumed to begin in 2003 and to occur at a similar rate among all age groups within a population. Whereas this was an optimistic scenario for the VISION 2020 initiative, we believed that it was reasonable for the following reasons. First, the prevalence of blindness from onchocerciasis, in particular, but also blindness due to vitamin A deficiency and probably trachoma, has been decreasing due to specific program activities and a general improvement in nutrition, water availability, and sanitation. Second, the global number of cataract surgeries has been increasing year by year. For example, the number of cataract surgeries in India has increased more than threefold during the last 10 years to almost 4 million cataract operations per year at present. Therefore, it is possible that the prevalence of blindness in developing countries could be as low as the prevalence in established market economies by the year 2020 if appropriate public health and medical interventions are undertaken.

RESULTS

IN TABLE 1, WE SUMMARIZED THE POPULATION DATA FROM the United States Census Bureau by WDR region, indicating the population in millions and the proportion of population in three age ranges, that is, 0 to 14 years (children), 15 to 64 years (adults), and 65 years and older (older adults). These figures were shown for 2000, 2010, and 2020. The global population was projected to increase from 6.1 billion in 2000 to 7.5 billion in 2020. The proportion of the population consisting of children was projected to decrease from 30% to 25%, whereas the proportion of the population consisting of older adults was projected to increase from 7% to 9%.

In Table 2, we projected the prevalence of blindness with and without the VISION 2020 initiative. The re-

TABLE 3. Estimated Millions of Blind Persons by Age Group and World Development Region With and Without VISION 2020

	2000	2010		2020	
	Millions	Without VISION 2020	With VISION 2020	Without VISION 2020	With VISION 2020
Age Group					
0–14	2	2	1	2	1
15–64	25	33	23	43	13
65+	17	22	16	31	10
Global	44	58	40	76	24
World Development Region					
China	8	10	7	14	5
Established market economies	2	3	3	3	2
Former socialist economies	1	1	1	1	1
India	10	13	9	18	4
Latin America/Caribbean	3	4	3	5	2
Mid-Eastern Crescent	4	6	5	8	3
Other Asia/Islands	6	9	6	12	4
Sub-Saharan Africa	9	12	7	15	4
Global	44	58	40	76	24

gional figures in the first column were originally presented by Thylefors and associates.[6] Given the population in 2000, the regional figures implied a global prevalence of blindness of 0.72%. Given the demographic changes illustrated in Table 1, the global prevalence of blindness in 2020 was projected to increase to just over 1% (75.9 million blind persons). The prevalence increased most rapidly in regions predicted to have a significant demographic transition over the next 20 years. This excluded the established market economies and former socialist economies, where the demographic transition has already occurred and sub-Saharan Africa, where the demographic transition has not been projected to occur through 2020. In Table 2, we also indicated that if VISION 2020 were as successful as projected, the global prevalence of blindness would decrease to 0.33% in 2020. Under these projections, the number of blind persons decreased to 24.4 million in 2020 despite world population growth.

In Table 3, we illustrated the number of blind persons in three age groups and by WDR region in 2000, 2010, and 2020 with and without the VISION 2020 initiative. If one assumed that each blind person were alive for the full year in which he or she represented a prevalent case, 429 million blind person-years would be avoided due to the VISION 2020 initiative (Figure 1).

The number of cases in the population aged 15 to 64 years increased from 25 million in the year 2000 to 33 and 43 million in 2010 and 2020, respectively without VISION 2020 but decreased to 23 and 13 million in 2010 and 2020 with VISION 2020. In Table 4, we illustrated separate figures for the annual productivity loss for blindness and low vision among unaccommodated employed 15- to 64-year-olds by WDR region. These figures were not discounted; they represented the actual loss in year 2000 US dollars. The global economic productivity loss for unaccommodated blindness alone was projected to grow from $19 billion in the year 2000 to $50 billion in the year 2020 without the VISION 2020 initiative, whereas the figure associated with blindness and low vision combined was projected to grow from $42 billion to $110 billion. These increases were the result of the increase in the 15- to 64-year-old population and the growth in GDP per capita. With the VISION 2020 intervention, the global figure for blindness increased from $19 billion to only $26 billion in year 2020 with the increase in productivity offsetting the decrease in prevalence; the figures were $42 billion and $57 billion for blindness and low vision combined. Counting low vision's costs more than doubled the loss.

In Figure 2, we illustrated a less conservative estimate of the undiscounted total economic productivity loss due to blindness, on a year-by-year basis from 2000 to 2020. In this case, we assumed that each case of blindness required 10% of a sighted adult's time and that the adults providing informal care are in the labor force and unemployed at the same rate as the general population. We also assumed that individuals aged 65 and older were one half as productive as individuals aged 15 to 64. In this case, the annual loss due to unaccommodated blindness increased from $29 billion to $77 billion without VISION 2020 but to only $41 billion with VISION 2020.

Using a 3% discount rate, the present value of this increase in economic productivity associated with fewer blind individuals with a successful VISION 2020 initiative was $151 billion. Including the impact of projected low vision cases resulted in an additional $159 billion for a total of $310 billion in present value of productivity increase over 20 years. This represented a drop from a

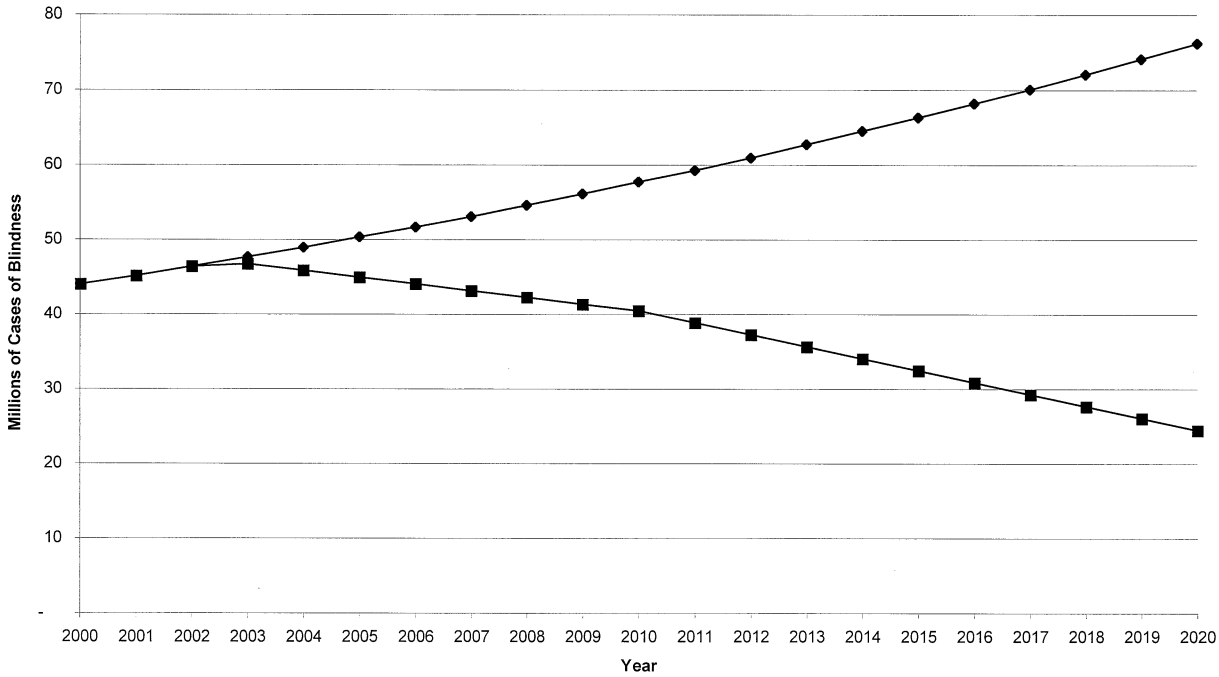

FIGURE 1. Number of cases of blindness with and without VISION 2020 (number of blind cases without VISION 2020 initiative [filled diamonds]; number of blind cases with VISION 2020 initiative [open squares]).

TABLE 4. Annual Global GDP Loss From Blindness* + Low VISION** Measured in Millions of Dollars

	2000	2010		2020	
WDR Region	Blind + Low Vision	Without VISION 2020	With VISION 2020	Without VISION 2020	With VISION 2020
China	1,330* + 1,576**	2,460* + 2,912**	1,706* + 2,020**	4,165* + 4,931**	1,451* + 1,719**
Established market economies	11,104 + 13,150	17,700 + 20,960	16,708 + 19,785	24,901 + 29,486	17,973 + 21,283
Former Socialist economies	358 + 425	566 + 670	535 + 634	750 + 889	542 + 641
India	805 + 953	1,458 + 1,727	1,012 + 1,198	2,538 + 3,005	613 + 725
Latin America/Caribbean	1,469 + 1,740	2,651 + 3,139	2,206 + 2,612	4,571 + 5,412	1,695 + 2,007
Mid-Eastern Crescent	919 + 1,089	1,746 + 2,068	1,376 + 1,629	3,117 + 3,692	1,093 + 1,295
Other Asia/Islands	2,398 + 2,840	4,572 + 5,415	3,005 + 3,558	8,128 + 9,625	2,370 + 2,807
Sub-Saharan Africa	838 + 992	1,324 + 1,568	767 + 908	2,003 + 2,371	514 + 609
Global	19,223* + 22,764**	32,477* + 38,459**	27,314* + 32,344**	50,172* + 59,412**	26,251* + 31,086**

GDP = gross domestic report; WDR = World Development Region.

present value of $1,546 billion lost without VISION 2020 to only $1,236 billion lost with VISION 2020. A similar figure counting only the effect associated with blind 15- to 64-year-olds and not including informal care was $102 billion gained.

DISCUSSION

AGING AND GROWTH OF THE GLOBAL POPULATION OVER the next 20 years were projected to lead to a large increase in the number of blind persons. This could be avoided by targeting existing and new resources at those causes of blindness for which proven interventions are available. The "VISION 2020—right to sight" initiative could decrease the number of blind persons to approximately one half of the current level. This would lead to a decrease of over $151 billion (present value) in economic loss from both unaccommodated blindness and informal care in the next 20 years, at an average of $7.5 billion per year (a figure similar to the gross national income of Ethiopia in 1999—$6.5 billion).[7] These figures doubled if a similar impact on low vision prevalence were assumed. The estimates (including the initial number blind—44 million

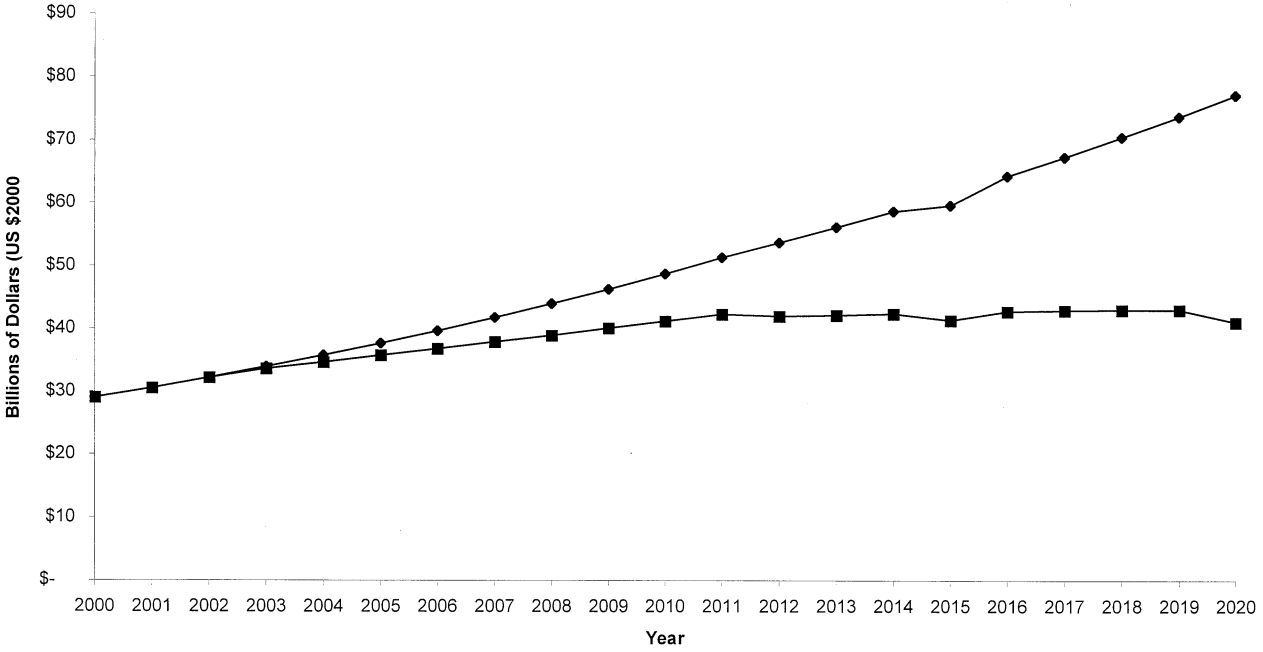

FIGURE 2. Annual economic productivity loss due to blindness for all age groups and including formal care with and without VISION 2020 (economic productivity loss without VISION 2020 initiative [filled diamonds]; economic productivity loss with VISION 2020 initiative [open squares]).

in 2000 in comparison with the WHO's projections of 45 million—obtained at the website mentioned in the introduction) were conservative.

The assumptions made in the methods section represent limitations to the study. The assumption of constant prevalence rates for 5-year age intervals from 2000 to 2020 did not allow for progress, that would occur with existing resources. Even without VISION 2020 there would be improvements in the control and treatment of diabetic retinopathy, age-related macular degeneration, or the five diseases that are the focus of VISION 2020. Importantly, even if all the gains from blindness prevention in the established market economies were not attributable to VISION 2020, the increased productivity in the year 2020 alone would still be $17 billion.

The results differed from those of Smith and Smith's; their estimates indicate a 1-year loss of $90 billion for blindness when adding the separate regional totals rather than using a single productivity figure for all individuals with blindness. This difference was driven by several different assumptions. The more conservative assumptions in this paper provided a useful estimate of the minimum economic impact of blindness, although we relied on the assumption of no opportunity cost for individuals who are not in the labor force or not employed.

Blindness and low vision are public health problems that will increase because of demographic trends unless there are additional interventions. Whereas accommodation of those who are already blind has the potential to yield economic improvements, VISION 2020 aims to eliminate avoidable blindness from five important diseases. If successful, this will result in a reduction of 429 million blind person-years and a minimum saving of $102 billion for unaccommodated blindness alone over the period from 2003 to 2020.

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