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What Is Low Vision? A Re-evaluation of Definitions

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ABSTRACT: *Purpose.* To re-evaluate definitions of low vision, visual impairment, and disability. *Methods.* We review current definitions of legal blindness and low vision and how these definitions are variably based on disability or impairment. We argue for a definite distinction being made between criteria for visual impairment and visual disability, low vision being defined as the presence of a visual impairment that results in a disability. Visual impairment is defined according to population norms and a statistical cut-off is used. Visual disability is defined by consideration of the level of visual measures which result in measurable or reportable disability. We consider the evidence that contrast sensitivity should be a criterion for visual disability in addition to visual acuity and visual field. *Conclusions.* According to the current information, we define visual impairment as best monocular or binocular visual acuity < (worse than) 6/7.5, total horizontal visual field <146° (Goldmann III-4e) or <109° (III-3e), and contrast sensitivity <1.5 (Pelli-Robson); we define visual disability as best monocular or binocular visual acuity <6/12 or contrast sensitivity <1.05. (Optom Vis Sci 1999;76:198–211)

Key Words: low vision, visual impairment, visual disability, visual acuity, visual fields, contrast sensitivity, legal blindness

What is low vision? We all think that we have the answer to this question, until we start to think more deeply. Then we find that the territory is far from clear and that the time is ripe for a new discussion of definitions. It is common to use the terms low vision and visual impairment almost interchangeably and yet there is no clear definition of when a person would be classified as having low vision. Guidelines have been suggested, but there is no consensus. However, eligibility for funding for low vision aids and other rehabilitative intervention and support services is often dependent on these classifications and definitions. For example, certain forms of financial assistance in the U.K. are dependent on registration as legally blind, but there are some that are also available to those registered as partially sighted. In Canada, obtaining the full services of the CNIB (Canadian National Institute for the Blind) is dependent on meeting the criteria for blind registration, but those who are visually impaired can also receive some of the services. In the U.S., blind registration is required to receive Supplementary Security Income (SSI) and Social Security Disability Insurance (SSDI), although visual impairment could contribute to assessment of overall disability for SSDI when the person has other, nonvisual disabilities. In addition, the adopted definitions will have an impact on research, e.g., in the reported prevalences of various severities of visual impairment in epidemiological studies or, indeed, in any studies on the effects of visual impairment. In this paper we will review the current variety of definitions, look at their implications, discuss whether an absolute definition of visual impairment is helpful, make some recommendations, and highlight some important questions which remain unanswered. We will discuss this primarily from considerations of access to rehabilitation, but there are other implications of definitions of low vision, e.g., in data gathering and interpretation in epidemiological studies.

Before we commence this discussion, we will review the World Health Organization (WHO)'s definition of disorder, impairment, disability, and handicap as they relate to vision and the following analysis will be couched in these terms.[1, 2]

Disorder: any deviation from the normal structure or physiology of the visual system, any physiological or pathological anomaly of the eye or visual pathway. For example, cataract is a departure from the normal clarity of the lens and age-related maculopathy is a departure from the normal structure and physiology of the retina.

Impairment: a measurable loss or departure of functional capability relative to the normal variation in healthy eyes, a psychophysical measurement which is outside the normal range. Impairment occurs as a result of a disorder; for example, visual acuity or contrast sensitivity which is decreased as a result of cataract. However, although all impairments result from a disorder, not all disorders result in impairment. Limbal corneal neo-vascularization (disorder) will not result in any measurable loss of visual acuity (impairment) unless the neo-vascularization encroaches into the pupil area.

Disability: the lost capacity to perform a certain task as a result of an impairment. A visual disability refers to any diminished or absent ability, because of a visual impairment, to perform a task involving vision that is needed to maintain one's desired life style. For example, a person has a visual disability if he/she is not able to drive a car, or is not able to read a newspaper, because of decreased visual acuity and who wishes to do so. This is generally interpreted as being without any specialized devices or aids. In low vision rehabilitation, this is the stage in the process at which we intervene. We attempt to decrease the disability by providing low vision aids or environmental modifications which enable the person to perform the task again.

Handicap: the actual or perceived social, economic, or psychological disadvantage which results from a disability. It would be measured by considering reductions in physical independence, mobility, economic independence (employment), and social integration. For example, a person who is not able to drive a car may be limited in his/her preferred employment options and may be limited in the social engagements that he/she would like to maintain.

In summary, disorder leads to impairment, which leads to disability, which leads to handicap. However, not all impairments result in disabilities and not all disabilities result in handicaps. Later in this paper, we will discuss this further, with particular reference to impairment and disability.

Disorder and impairment relate to the organ or part of the body, not to the individual. Presumably, every person with an identical disorder and severity or combination of disorders would suffer the same impairment. However, the definitions of disability and handicap relate to the person as a whole and take into account the different preferences and chosen life styles of individuals, so that the same impairment in different individuals may not result in identical disability and handicap. In fact, impairment may not lead to disability and handicap at all, because both disability and handicap relate to the particular individual's preferences and desires. For example, for the person who has never owned a car, having visual acuity which falls below the legal driving standard would not be a disability or a handicap because it has no impact on his/her activities or resultant life style. However, for the travelling salesperson, this would be a grave disability resulting in handicap, probable unemployment, loss of earnings, and a decreased standard of living.

THE VARIABILITY OF CURRENT DEFINITIONS

Legal blindness

We will start by reviewing some of the definitions of legal blindness and low vision. Most countries will have a definition of legal blindness but few have a definition of low vision. Historically, such definitions fall into two categories: those that are functionally based (based on disability or handicap) and those that are measurement-based (impairment), which depends on visual acuity and sometimes with an additional visual field criterion. In some cases, there is a functional definition with a visual measure guideline. For example, the WHO defines blindness as "the inability to perform tasks which normally require gross vision without increased reliance on other senses."[3] The equivalent visual impairment measure for blindness is less than 3/60 or visual field less than 10°.[4] In Britain, the definition is also functional with a visual acuity and visual field guideline. A person is legally blind if he/she is "unable to perform any work for which eyesight is essential." This is the legal definition, but the visual acuity guideline is <3/60 (10/200)[5] (in this paper, < means poorer or worse than). There are additional categories if fields are also constricted; less than 6/60 with very contracted field, or 6/60 and better with very contracted field especially in the lower field. However, there is some suggestion that the visual acuity guideline (with full fields) will be relaxed to ≤3/60.[6,7] In addition, because ophthalmologists in Britain rarely record 3/60, but instead jump from 6/60 to counting fingers, the practical outcome is that the guideline becomes <6/60.[8] Also, it must be noted here that ≤3/60 is equivalent to <6/60 if a Snellen chart is used which has no letters between 3/60 and 6/60 and if the viewing distance is not altered. The difference would only be detected with a logarithm of the minimum angle of resolution (logMAR) chart which includes these lines.[9,10] This emphasizes the need for standardization of charts when defining visual acuity and for the need of proper quantification of visual acuity, rather than measures such as "count fingers." Obviously, the latter is not standardized, the distance, digit width, color, and contrast all being variable. Most fingers are approximately equal in width to a 60-m letter, so that the patient who is capable of counting fingers should be able to recognize a 60-m letter at the same distance, i.e., if they can count fingers at 1 m, they should be able to obtain 1/60. Thus, their visual acuity can and should be properly quantified. In fact, a quantifiable measure of visual acuity down to at least 0.5/60 by bringing any Snellen or logMAR chart to 0.5 m is easily attainable and should be attempted. There are several sources of confusion and differences of interpretation in the British system: first, the fact that the statutory definition is based on disability, not impairment; second, the use of Snellen charts, rather than logMAR charts; and third, the use of nonstandard measures such as count fingers. This has resulted in confusion with different visual acuity limits being quoted in different sources.[6,11] In Australia, the definition is also disability-based, being "permanent incapacitation for employment," but it is also statutorily defined as visual acuity that does not exceed 3/60 in either eye with additional criteria in cases of reduced fields.

In the U.S. and Canada, the definition is impairment-based; best corrected visual acuity of ≤20/200 or a visual field not greater than 20° in any meridian.[12] Several African countries (Nigeria, Ghana, Senegal, and Gambia) use a similar definition. In Canada, those who fall within this definition are eligible for all the services of the CNIB. All these definitions are based on best corrected visual acuity and assume that the visual impairment is long-standing and that all possible treatment has been recommended or attempted, and includes visual impairment due to any cause (media, retinal, cortical).

In general, these definitions are attempting to define a group of people with a certain level of visual disability (who therefore need help), but with the recognition that some sort of measuring stick is needed (and thus the impairment-based definitions). Those who fall into the category of legal blindness have a severe visual impairment, and few would disagree that they should be eligible for financial help and rehabilitative intervention in order to maintain a reasonable standard of living and quality of life. Societies which recognize and provide for this need benefit indirectly, by allowing legally blind people to maintain independence. However, it is commonly recognized that there are many individuals who are not legally blind, according to these definitions, but who have a definite disability due to a visual impairment and who need the resources of a visual rehabilitation center or low vision clinic. Such needs have motivated definitions of low vision.

Low vision

The term low vision was introduced by Faye and Fonda, and brought into common usage by the writings of Faye and her work at the Lighthouse Low Vision Service in New York City. Terms previously (and still) used to recognize vision loss that is significant and disabling, but which does not fall within the legally blind category, were subnormal vision, partial sight, or partial blindness. The definitions of low vision are just as varied, if not more so, than those of legal blindness. In Britain, there is a second category, known as partial sight, which may make a person eligible for certain financial benefits, e.g., Severe Disablement Allowance, Disability Premium, and free public transport in certain areas.[13] Again, a functional definition is used with an interpretation guideline in terms of visual acuity. Partial sight is defined as defective vision of a substantially and permanently handicapping nature caused by congenital defect, illness, or injury and is interpreted as visual acuity between 3/60 and 6/60 with full field, up to 6/24 with moderate contraction of the field, and 6/18 or better with gross field defect.[5, 11] Nonetheless, even this definition, more lenient as it is, excludes many people who experience visual disability. In Canada, those who do not fall within the definition of legal blindness mentioned above, but who have a visual impairment, can obtain some of the services of the CNIB. However, there are no clear guidelines of what constitutes a visual impairment according to the CNIB. In the U.S., schools use partial sightedness for eligibility into programs for the visually impaired. Visual impairment is defined by the Social Security Administration as visual acuity <20/40.[14, 15] The National Center for Health Statistics in the U.S. defined severe visual impairment in adults as being those who are unable to read the newspaper even with the aid of conventional lenses.[12] The WHO defines low vision according to both disability and impairment—moderate low vision is the "ability to reach near normal performance with visual aids" and in terms of impairment is <6/18.[1, 3] The National Institutes of Health in the U.S. adopts the same definition, i.e., <6/18 but, as they point out, this definition excludes some people with field loss.[16]

In the low vision literature we find less disagreement regarding the visual acuity level at which people will begin to need the services of a low vision clinic. Mehr and Fried[17] and Robbins[18] define low vision as visual acuity of less than 6/18, which is also in agreement with the WHO. However, Faye[19] defines low vision as subnormal visual acuity or abnormal visual field resulting from a disorder. This is a less stringent criterion (see discussion below). Nowakowski[20] suggests that we should use a functional definition of low vision, being "vision that is not adequate for a person's needs." Unfortunately, this may include people with normal visual acuity whose job requirements are visually very demanding, e.g., a watch maker or cardiac surgeon, who require magnification despite normal visual acuity. As he says himself, "everyone could be considered visually impaired for some tasks." Therefore, this definition does not help to determine eligibility for low vision services and financial aid because of a disorder.

Studies on low vision clinic populations may be of value here. We can gain information regarding the range of visual acuity seen in each clinic. This implies that people within this range are seeking help from a low vision clinic. Perhaps we should use the public themselves to define the cutoff for impairment by their implied visual disability in seeking out help (voting with their feet). Leat and Rumney[21] show that some patients with visual acuity as good as 6/6 attended a low vision clinic. Robbins[22] shows the best presenting visual acuity of 6/9.5 (one patient only) and Humphry and Thompson[23] show a number with 6/12. Yap et al.[24] do not show a significant number until visual acuity is 6/18 or worse and Kleen and Levoy[25] show no patients with visual acuity better than 6/21. However, this approach is not reliable as we are usually not given the total information, i.e., the disability may have been primarily due to field constriction or contrast sensitivity loss rather than visual acuity loss. In addition, there is sometimes misunderstanding regarding the services provided at a low vision clinic. There may be occasional patients who are not visually impaired, or who can be corrected to normal visual acuity by an accurate refraction,[21] particularly in any clinic that is open to self-referral. Other clinics do not have a self-referral policy, patients being referred from other practitioners. This will also bias the statistics because of the referring clinicians' own bias regarding what visual acuity constitutes a visual impairment requiring intervention. The statistics may reflect the clinicians' perception rather than the genuine visual disability of clients.

In the absence of any definitive guidelines of what visual acuity level constitutes low vision, epidemiological studies have each adopted their own criteria, which have been either functional or measurement-based. Self-report surveys in Britain and Canada used a similar visual disability definition which was "not being able to read a newspaper or not being able to recognize a face across a room even with conventional glasses."[26, 27] The National Center for Health Statistics in the U.S. uses a similar definition of not being able to read a newspaper, but also includes the phrase "other problems seeing with one or both eyes."[12] The Lighthouse Inc. follows this trend,[28] including the additional categories of "blind in one or both eyes or some other trouble seeing, even with glasses." These definitions introduce a greater element of subjectivity and would also include people who are monocular, but have normal vision in one eye. These people would not be classified as having low vision according to the usual understanding, which specifies low vision in terms of the visual acuity in the better eye. Both the Baltimore Eye Survey[29] and the Salisbury Eye Evaluation Study[15] used two criteria to define visual impairment, best visual acuity <6/12 and visual acuity <6/18, whereas the Beaver Dam Study[30] defined mild visual impairment as visual acuity 6/12 to 6/18 and moderate visual impairment as <6/18. These different definitions make it difficult to precisely compare statistics among the studies, and therefore between geographic areas, ethnic groups, and countries. Clearly, there is a need for some generally agreed standard.

We have seen that some definitions are disability-based and others are impairment-based. This begs the question: Should access to services be based on impairment or disability? Interestingly, cataract surgery is generally available based on either impairment or disability. The advantages of a disability-based criterion is that this takes into account the whole person and allows some flexibility of interpretation. It is the disability, not the impairment, which results in a need for rehabilitation. The exception to this is cases in which a disorder is progressive, leading to certain severe disability and in which special skills, e.g., Braille, may be best learned while some vision remains or while the person is of a particular age.

Generally, if there is no perceived disability, there is no need for intervention. Those who work in optometric primary care or low vision clinics will occasionally meet the patient who, despite a considerable visual impairment, may have no apparent rehabilitation needs. One factor which gives rise to this situation is low visual demands, e.g., no wish to read or drive. This may be due to the individual's choice or cultural demands or expectations. Another factor is the patient's desire and need for independence. For example, some patients prefer dependence, and the social contact that it brings, to independence. However, the disadvantage of a disability-based definition is that it is open to variable interpretation, so that a person's eligibility is dependent on the clinician's judgment. Services may be withheld from a person who genuinely requires them, on the basis of a very rapid clinical assessment of disability. Registration for legal blindness or partial sight is commonly made by an ophthalmologist or family doctor, who may not have the time to undertake an in-depth assessment of disability. It may be argued that all people with a given degree of visual impairment are likely to need intervention, assuming a "normal" life style in modern technological society, and that services should be available to them on request; at the very least, this approach is more equitable.

There are two interests with potential conflict being represented when funding for rehabilitation and devices is concerned: that of the body making payments and that of the individual with the disability. These two are not necessarily in agreement. The paying body may err on the side of conservatism, being responsible for public or corporate funds and therefore wanting full assurance of genuine disability before making a payment. The person with the disability (or the body representing them) may want more free access to funds in order to ensure that nobody who requires aid is denied it. If too conservative a line is taken by the paying body, people with genuine needs may be denied. If too lenient a line, then the system is open to abuse, particularly when devices with considerable intrinsic value are counted as low vision aids. For example, computer systems can be provided as writing and reading aids, e.g., giving access to newspapers on the World Wide Web, yet they have value to other people without disabilities. With these two potentially conflicting interests, we desperately need a greater understanding of what constitutes a visual impairment and what levels of visual impairment are likely to lead to a disability. This can be thought of as an objective measure (impairment), including an understanding of what levels of impairment results in disability in order to prevent unnecessary spending or abuse of the system, and a subjective measure (self-reported disability/patient needs and goals). In policy making for funding of treatment, cost effectiveness is another aspect to be considered. We have not included that analysis in the present discussion. The purpose of the current paper is to distinguish that portion of the population which is likely to benefit from services and which should be included in any discussion of eligibility for services. In this paper we attempt to provide some guidelines.

TOWARD A STANDARD DEFINITION

Visual impairment

The most commonly reported aspects of visual function to be associated with visual disability are visual acuity, visual field loss, and contrast sensitivity loss.[31–33] Visual acuity and field loss are the traditional measures used to classify visual impairment; therefore, we will concentrate our discussion on these three variables.

Let us look again at the definition of visual impairment as being a measurable loss in a psychophysical visual measurement, because of a disorder, which is outside the normal range for eyes which do not have a disorder. What is the normal range? Many psychophysical measures, in the absence of disorder, follow a normal distribution and we could take the 95% confidence limits of normal as being the normal range. Is this a reasonable cut-off? This would mean that the 2.5% of people without a disorder would have vision equal to those who we would classify as having a visual impairment resulting from a disorder (2.5% having vision better than the normal range—in the current discussion we are only interested in those who fall outside of the normal range at the poorer end). This seems rather high; perhaps we should take a more stringent cut-off and take the 99% confidence limits. Therefore, this would mean that only 0.5% of people without a disorder would have similar vision to those classified as visually impaired, which seems more reasonable.

Visual acuity

We will start by pursuing this discussion in terms of visual acuity. Table 1 shows the results from a number of studies which measured visual acuity in a normal population. Here we have only included studies which exclude subjects with visual disorders, check the refractive correction, and use letter tests of visual acuity which allowed a small enough measure of visual acuity to prevent a floor effect and which report a value of both mean and standard deviation. This excludes many studies. For example, Elliott et al.[34] collated normal data on visual acuity from a number of previous studies. We have not included these data here because they used an additional exclusion criterion of visual acuity less than 6/7.5 or less than 6/9 which would artificially cut off the normal range at the poorer end and thus influence the standard deviation. Ehlers[35] and Wild and Hussey[36] do not state any exclusion criteria for pathology.

It should be noted that the data presented by Brown and Lovie-Kitchin[37] are the mean of 10 measurements for each subject. This would have the effect of decreasing the overall standard deviation of the population in a small sample. Frisen and Frisen[38] and Elliott and Sheridan[39] presented their data in decimal acuity. These have been converted to logMAR, but this process may lead to a loss of accuracy.

TABLE 1.
Mean and 99% confidence limits of normal monocular visual acuity.

Study	Age Group (yr)	Mean Visual Acuity		99% Confidence Limit[a]	
		logMAR	Snellen	logMAR	Snellen
Frisen and Frisen[38b]	20–29 (N = 20)	−0.146	6/4.3	0.038	6/6
	30–39 (N = 20)	−0.114	6/4.6	0.001	6/6
	40–49 (N = 21)	−0.146	6/4.3	0.058	6/7.5
	50–59 (N = 13)	−0.107	6/4.6	0.027	6/6
	60–69 (N = 9)	−0.08	6/5	0.163	6/9
	70–79 (N = 5)	−0.05	6/5.4	0.109	6/7.5
Elliott and Sheridan[39b]	64 (N = 20)	−0.049	6/5.4	0.0511	6/7.5
Brown and Lovie-Kitchin[37]	18 (N = 10)	−0.163	6/4	0.051	6/7.5
Beck et al.[62c]	18–46 (N = 140)	−0.125	6/4.5	0.144	6/9

[a] Mean + 2.575 × SD. Snellen figures are rounded to the nearest Snellen line.
[b] Calculated in decimal and converted.
[c] Mean for OD and OS.

The mode of the 99% confidence limits of the studies in Table 1 is 6/7.5. The mean is 6/7.1. So in practice we could say that visual acuity worse than 6/7.5 indicates a visual impairment which, with the use of Snellen or logMAR charts, is equivalent to 6/9 or worse. Visual acuity measurement for impairment or disability assessment should be measured with a logMAR chart with 0.1 log steps over the entire visual acuity range, and with control of contour interaction (proportional letter and line spacing) and the same number of letters per line (charts made according to this specification generally have five letters per line).[40] It must also be noted that the use of a cut-off in terms of standard deviation units presupposes a Gaussian distribution. The use of Snellen rather than logMAR charts and the exclusion criteria chosen would influence whether a true Gaussian distribution is obtained.

It is worth noting that average visual acuity decreases with age and this trend can be seen in the data of Frisen and Frisen. This could lead to the development of an age-dependent criterion for visual impairment, e.g., less than 6/6 for 20- to 39-year-olds and less than 6/7.5 for 50 and upward. There are also anomalies in Frisen and Frisen's data in that the 50- to 59-year-olds perform better than the 40- to 49-year-olds. This is presumably an anomaly due to small sample size. At present, we have chosen a single criterion for visual acuity for simplicity, based on data from older people (similarly for fields and contrast sensitivity below), but the possibility for age-related criteria must not be dismissed.

This criterion means that when a visual acuity of less than 6/7.5 is measured, that person is highly unlikely to be part of the normal distribution and is most likely to have a disorder. Clinically, we should search for a cause for the reduced visual acuity and only classify a person as an outlier in the normal distribution after proper investigation. It should be noted here that bilateral refractive amblyopia would be classified as a disorder. Although there is no abnormality that can be viewed, there is an assumed disorder at the cortical level. These people would be classified as visually impaired if visual acuity is 6/9 or poorer. As with any measure of visual performance, there is variability between measures on different days. The 95% confidence limits for test-retest repeatability is commonly 0.06 logMAR[38] but can be as much as 0.19 for early pathology,[41] and this must be taken into account when borderline measures of visual acuity are obtained (repeated measures should be used before labeling such a person as visually impaired, particularly in the case of borderline visual acuity or when subjective disability is not consistent with measured visual acuity).

We should also note here that there is a difference between the criterion for visual impairment classification and that for clinical concern or for screening. When deciding whether to investigate the cause of possible reduced visual acuity in an individual patient, a less conservative criterion should be used. Then it would be more appropriate to take the 95% range of normal which is −0.0188 logMAR = 6/5.7, i.e., any visual acuity less than 6/6 would be suspect. Actually, a more accurate method, if previous visual acuity measures are known, is to look at the change in visual acuity.[37, 41] Ariyasu et al.[42] propose the use of a higher visual acuity limit for screening purposes. In the case of screening, both sensitivity and specificity must be considered. In the current situation (defining visual impairment), we argue that a high specificity is more important than a high sensitivity. We are not attempting to identify patients with a visual disorder so much as to identify those with a visual acuity outside the normal range.

Visual fields

We would like to apply the same criterion to visual fields. However, there are few data giving visual field norms with standard deviations, and any existing data are particular to the exact instrument used. In addition, we would like one figure which would characterize the whole binocular (functional) visual field. This is difficult to do with such a multifaceted measure as a visual field plot. The Humphrey Field Analyzer gives a mean deviation score, which describes the central visual field and its variation from the age-related normal. However, these age-related norms are not published and we are only given the mean deviation in terms of percentile of the normal distribution in the case of a given field plot. In addition, the Humphrey Field Analyzer uses a factor to correct for the increasing variance found in the peripheral field. This correction factor has never been published and, hence, it is impossible to calculate overall standard deviations for the population. Normal data on the Octopus automated perimeter (Table 2) shows that the

TABLE 2.
Visual field norms.

	Mean and SD	99% Confidence Limits for Normal
Octopus automated perimetry[43] (mean age 48 ± 17 yr)		
Mean defect	0.2 dB ± 1.5	4.1 dB
Corrected loss variance	1.5 dB ± 2.6	18.9 dB
Goldmann perimetry[45] (age 60–69 yr)		
Target and meridian of visual field		
III-3e, temporal	76.3° ± 8.5	54.4°
II-3e, inferior	64.0° ± 3.7	54.3°
III-4e, temporal	84.0° ± 4.4	73.0°
III-4e, inferior	70.4° ± 4.6	59.6°
III-4e total monocular field (8 meridia)	438°	389°

upper limit of normal (99% confidence) is 4.06 dB for mean deviation (defect) value and 18.9 dB for corrected loss variance (a measure of the variability across the visual field).[43] The Friedman Visual Field Analyzer does not give an overall score that can be used in this way. The Henson Perimeter can be used as a suprathreshold screener or to give a full threshold plot. In the former mode a scale is given of normal/suspect/defect, with an arrow showing the patient's position on the scale. The division between normal and suspect is the 90% confidence limit and between suspect and defect is 99.9%.[44] Neither of these meet with our criterion of 99% suggested above. However, there is also questionable value in using either mean defect or pattern deviation for determination of visual impairment and disability. First, these scores were primarily developed for the detection of glaucoma. Second, the pattern deviation is not linearly related to the degree of visual field loss. Although sensitive to early glaucomatous loss, the value of pattern deviation may decrease as the visual field loss increases. The mean deviation does not weight different parts of the field and therefore is not ideal for determining disability, because not all parts of the field have equivalent functional value (see below).

Williams[45] published normal data for the Goldmann perimeter for the III-3e and III-4e targets and the results are shown in Table 2. The 99% confidence limits are a total horizontal extent of 109° for the III-3e target and 146° for the III-4e target. Summing all 8 meridia from Williams' data gives the total mean monocular field of 438° (III-4e), which is smaller than the 500° normal field quoted by The National Research Council.[40] The 99% confidence limits are even smaller (389°). There is a major disadvantage of kinetic perimetry—it is subject to operator variability.

It must be noted that there is more test-retest variability in abnormal (glaucomatous) fields than normal fields. Heijl et al.[46] showed that glaucomatous fields have such a variability that, at visual field locations with a moderate loss, measurements may be within the normal range on some occasions. This emphasizes the need for repeated measures (as has already been discussed for visual acuity) before a decision regarding visual impairment is made, in cases of borderline loss.

Traditionally, most standards for visual field loss were defined by kinetic techniques (see below on driving standards), but these standards are becoming less useful, given the switch to computerized perimetry. It is not easy to extrapolate from static to kinetic measurements. For comparison between kinetic and static perimetry, The National Research Council[40] suggests the use of full-field supra-threshold static protocols on the Humphrey and Octopus perimeters and that the edge of the visual field should be interpolated as halfway between seen and unseen stimuli.

It would be advantageous to have a standardized method that could be applied to a number of instruments. Esterman[47] has suggested a grid which weights different areas of the field according to the functional significance of loss in each area. Thus, the center of the field is weighted most heavily and the superior periphery is given least weight. This is in agreement with the more recent findings of Lovie-Kitchin et al.,[48] who found that, when the field is measured in equal solid angles, the central 37°, followed by the lower, left, and right mid-periphery are most important for mobility. Esterman grids have been developed for central fields, peripheral fields, and binocular fields and could be adapted for use with a number of different field instruments. However, there are no published data for norms based on the Esterman grid. Drasdo and Peaston[49] suggest three similar techniques based on equal solid angles of visual field, equal retinal areas, or equal cortical representation. All of these techniques give more weighting to the center of the visual field than conventional plots. Equal solid angles and retinal areas give less weighting to the center of the field than Esterman's technique, whereas equal cortical representation gives much greater weighting. These techniques are easy to apply when there are absolute scotomata, but the question of how to deal with relative scotomata has not been solved. Others have developed similar methods.[50] In addition, it is the binocular field with which we are concerned. A scotoma that is only present in one monocular field will not generally give rise to a binocular, functional loss as the intact field of the other eye detects the target. Esterman suggests actually measuring fields binocularly. For impairment and disability purposes, some standardized methods of measuring binocular fields should be considered.[40] However, Arditi[51] points out that this may result in lost information and a misunderstanding of the true functional field loss. Scotomata in the two eyes may not overlap in the fixation plane, but a volume scotoma can occur in three-dimensional space, i.e., nearer or further than fixation, depending on the relative positions of the scotomata in each eye and the convergence of the eyes. Therefore, it would be more appropriate to continue measuring monocular fields with standardized methods and combine them for the purpose of establishing impairment.

Contrast sensitivity

Although contrast sensitivity has not been included in the traditional classification of visual impairment, there is a body of evidence that reduced contrast sensitivity is as visually disabling as visual field loss and can be more disabling than visual acuity loss. Aspects of contrast sensitivity have been shown to be correlated with function for various daily living tasks including reading performance,[52–54] mobility,[55] perception of faces,[56] perceived disability,[32, 57] and difficulty with daily tasks.[33] Contrast sensitivity has been shown to be a better predictor of mobility performance than visual acuity.[55] In addition, contrast sensitivity loss can be present when visual acuity and fields are relatively intact,[58] and there is a large variation in contrast sensitivity loss even with the same ocular pathology.[59] Using the present definitions of low vision, such persons may be classified as being far less visually impaired than they truly are.

In light of the above evidence, we propose that contrast sensitivity should be taken into account in definitions of visual impairment. So the next question is: What level of contrast sensitivity constitutes a visual impairment and what clinical test should be used to measure it? The current trend is toward letter tests of contrast sensitivity, and the most commonly used and reliable are the Pelli-Robson and the Regan or Bailey low contrast charts. Leat and Woo[54] have shown that the Pelli-Robson is a good estimate of contrast sensitivity at low and medium frequencies and correlates with reading performance. It is generally considered to be desirable to measure contrast sensitivity at a low or medium spatial frequency or the peak of the spatial frequency curve because high frequency contrast sensitivity can be expected to correlate with visual acuity and therefore provides little additional information. Elliott et al.[60] and Elliott and Bullimore[61] present normal data using the Pelli-Robson chart. For the older age group in both studies (mean age of 70 years), we calculate the 99% confidence limit as 1.54 and 1.51, respectively. The data presented by Beck et al.[62] are similar. They find that "almost 100%" of younger observers obtained a value of 1.60. Based on the data for older observers, we conclude that anyone with a best monocular contrast sensitivity of less than 1.5 would be classified as visually impaired. Low contrast visual acuity is another method of estimating the contrast sensitivity for intermediate and high spatial frequencies.[54] Although there is some doubt over how much additional information is gathered by the use of high contrast visual acuity charts,[63] we will include some data here for the sake of completeness. Regan[64] shows that the lower limit (99% confidence limit) of the normal adult population (19 to 49 years) is 6/12 (0.3 logMAR) for his 7% contrast chart, i.e., a low contrast visual acuity of less than 6/12 would be considered a visual impairment. The 99% limit from the data of Elliott and Bullimore[61] for an older group (mean age 70 years) is 0.45 logMAR (6/17) for the 11% chart and 0.25 logMAR (6/11) for the 25% chart. Although they find a considerable difference between the age groups, we will use the data for older observers here. There is also a low contrast version of the Bailey Lovie visual acuity chart; 99% confidence limits for this, with older observers, is 0.5 logMAR (6/19).[61]

It must be noted that the norms quoted above are for monocular measurements. While discussing visual acuity and contrast sensitivity, we have limited ourselves to the consideration of monocular function because most definitions of low vision/legal blindness, etc., rely either on the best monocular performance,[14, 29] or best monocular or binocular performance.[5] These definitions may be assuming that binocular (habitual) performance is better than monocular. However, although persons with normal vision generally demonstrate binocular summation (performance on binocular tests being up to 42% better than on monocular tests), those with unequal visual acuity in the two eyes may have binocular performance equal to or poorer than (binocular inhibition) performance on monocular tests.[65, 66] The difficult situations to judge are those for whom binocular performance is equal to or poorer than monocular. These people have a greater impairment than indicated by their monocular function because they are being compared against a normal population with summation. Perhaps the case for most concern is that of the person whose binocular (and habitual) vision is poorer than monocular. In this case, it would seem more meaningful to base decisions on their poorer binocular performance.

The same discussion that we have used thus far with visual acuity, visual fields, and contrast sensitivity can be used with any visual function measure to decide on visual impairment. According to the definition of visual impairment quoted above, any measure of visual function which falls outside the normal range indicates a visual impairment. Thus, an abnormal measurement of glare sensitivity, dark adaptation time, stereopsis, dynamic visual acuity, color vision, or any other visual measure could be classified as a visual impairment and could give rise to a disability in a particular individual. For example, a person who has a color vision defect and wishes to be an interior decorator could consider themselves visually disabled and handicapped. However, it is generally thought that these other measures have a smaller effect on the ability to perform common daily living tasks undertaken by an average member of the population. This is confirmed by the study of Rubin et al.,[33] who found that visual acuity and contrast sensitivity were associated with self-reported disability for a group of community-living adults over 65, whereas disability glare and stereopsis were not. Visual field loss was not added into the analysis in this study.

Therefore, our current understanding indicates that visual acuity, visual fields, and contrast sensitivity are the primary forms of visual impairment (summarized in Table 3) that give rise to disability. However, losses in other visual domains cannot be discounted and may limit performance for more specific tasks or occupations, in which case they should be considered as disabilities.

The final suggested definitions of visual impairment are shown in Table 3. Because there is considerable debate over the validity of scores from automated perimeters for determining visual impairment, we have only included the Goldmann results in this table. Also, because both the Goldmann III-3 and III-4 targets are used in other current definitions of field loss, we have included both in Tables 2 and 3.

Disability

We will now discuss what level of visual acuity is likely to cause a disability in common tasks. There are few studies of this. This

TABLE 3.
Definitions of visual impairment.

Visual Acuity	logMAR <0.1 which is Snellen <6/7.5
Visual fields (Goldmann)	<109° total horizontal extent (III-3e) or <146° (III-4e)
Contrast sensitivity (Pelli-Robson)	<1.50
Contrast sensitivity (Regan)	11% chart: <0.45 logMAR 25% chart: <0.25 logMAR

question has two parts: What are common and important tasks at each age and what level of visual acuity is required to accomplish these tasks?

In a questionnaire study of 63 adults with low vision due to a variety of pathologies, with ages ranging from 36 to 87 years, we asked the importance of certain tasks. Participants were asked to rate the tasks as very important, important, slightly important, or not important at all. The results are shown in Fig. 1. It can be seen that the most important task was reading medicine bottle labels. Other highly important tasks were reading bank statements, handwriting, bills, and leisure reading. Unexpectedly, reading the newspaper or regular books was important for fewer people. It may be the case that by leisure reading, some people mean reading newspapers, whereas others mean reading regular or large print books. This may explain why leisure reading is important for more people than newspapers, regular print books, and large print books. Interestingly, seeing photographs was as important as reading for leisure. These results indicate that various reading-related tasks are very important to adults. Indeed, as most clinicians know, and as Tobin and Hill[67] have documented, reading is the primary presenting concern for most adult low vision patients. Elliott et al.[68] report that reading was the primary objective for 75% of the elderly when attending for low vision rehabilitation, and the secondary objective for 21%. The overall second most common objective was help with daily living skills. The data of Hall et al.[69] also suggest this. They found that reading was the most frequently expressed need in low vision patients, followed by writing, recreation, home skills, and mobility, respectively. Unexpectedly, driving was at the bottom of their list, with only 8% of people expressing a need to drive. Of course, it may have been that the people in this population have already given up driving.

Although there have been many studies linking aspects of vision with disability,[31–33, 55, 70] there have been few studies which have given an indication of what decrease in visual function is possible

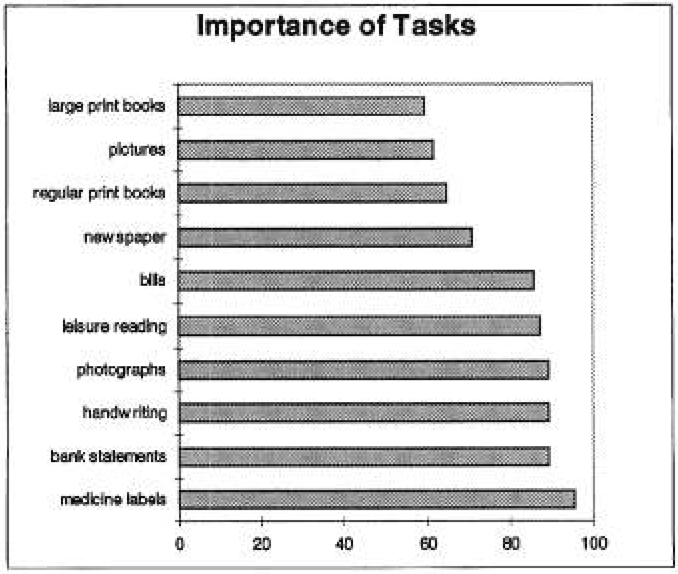

FIGURE 1.
The frequency with which a group of low vision patients answered that each task was very important or important to them. The question was: "How important is each of these tasks to you?" The answers were: 1. Very important; 2. Important; 3. Slightly important; and 4. Not at all important.

before a visual disability occurs. We will rely on existing data and theoretical calculations in the following discussion.

Being able to read the newspaper with an ordinary spectacle correction has been used in a number of studies on prevalence of low vision (see above). Newspaper print has a wide variation both between and within newspapers. The minimum print is 0.7 M (classified ads, sports pages, and obituary sections). To read all sections in 75% of newspapers, a person must attain 0.8 M.[71] We have based the following discussion on a 33-cm distance. Although this is a nonstandard distance (the distance of 40 cm being more commonly used), we have adopted it because many optometrists would prescribe an add up to 3 D before considering it a high add and most patients would easily accept this slightly closer reading distance (in fact, for many women, it is habitual). Using the standard 40-cm distance would mean that the required acuities would be approximately 0.1 logMAR or one Snellen line better than those shown. To read 0.8 M at 33 cm, a person would theoretically require a visual acuity of 6/15 (rounded to the nearest Snellen line). This would give them the equivalent of spot reading, only 44 words per minute.[53] This is not sufficient for reading a book or any other lengthy material. For maximum reading rate, low vision observers require an acuity reserve (ratio of text being read to word reading acuity) between 3:1 and 12:1[53] and normally sighted observers require 6:1 to 18:1. In low vision work, we rarely achieve these optimal reading rates with optical devices and many low vision practitioners will aim for a reserve of at least 2:1. Whittaker and Lovie-Kitchin suggest a reserve of acuity of at least 1.5:1 for fluent reading (80 words per minute). For more near-normal reading rates of 160 words per minute, they suggest a minimum reserve of 3:1, but in most cases this will not give optimum reading speed. In Table 4 we have shown the theoretical visual acuity required for 1.5, 2, and 3:1 reserves. This is a continuum, with most people increasing fluency as the reserve increases up to a maximum. Where we place the cut-off for disability is therefore questionable. To obtain moderate fluency (less than optimal) for newspaper print (0.8 M) at 33 cm, a visual acuity of 6/10 would be required (1.5 × reserve), but to obtain more near-normal reading rates, 6/4.8 is required. In fact, this is exactly the reserve that most people with a normal visual acuity of 6/4.5 (see Table 1) use to read the newspaper. In other words, any reduction in visual acuity will make reading slower. All these values assume high contrast of the print. In the case of poor contrast, reading rates for people with low vision would be further compromised in many cases.[52] See the Appendix for calculations.

However, as stated above, reading the newspaper is not rated the most important task, compared to other reading tasks. Table 4 gives the print size of other reading tasks and the theoretical required visual acuity with and without acuity reserves. These are limits based on considerations of resolution alone. Often, actual reading may be poorer (occasionally better) than letter acuity would predict. The task of reading text is more complex than reading a letter chart and is influenced by the following factors: presence of greater crowding effects and need for more accurate eye movement control (making reading more difficult) and potential use of contextual and word shape clues (making reading easier).[72] However, in the absence of other data, we have based our discussion on the theoretical limits imposed by resolution. It can be seen from the table that a visual acuity of 6/15 would allow a person to

TABLE 4.

Print size of common reading tasks and the theoretically required acuity to be able to resolve the print and to read fluently (1.5:1 reserve) or with high fluency (3:1 reserve) based on Whittaker and Lovie-Kitchin.[53]

Print Type	Equivalent M Notation	Point Size	Required Acuity for 33 cm	Required Acuity for 33 cm Allowing 1.5:1 Reserve	Required Acuity for 33 cm Allowing 2:1 Reserve	Required Acuity for 33 cm Allowing 3:1 Reserve
Medicine bottle labels	0.4	3	6/7.2	6/4.8	6/3.6	6/2.4
Newspaper obituaries, sports, and classified ads	0.8	6	6/14.4	6/9.6	6/7.5	6/4.8
Telephone directories	0.8	6	6/14.4	6/9.6	6/7.5	6/4.8
Newspaper front page articles	1.2	9	6/21.6	6/14.4	6/10.8	6/7.2
Typing	1.2	9	6/21.6	6/14.4	6/10.8	6/7.2
Computer display (80 column and 50 cm distance)	2	14	6/24	6/16	6/12	6/8

read (slowly) everything except medicine bottle labels and to read newspaper articles and typed print with some fluency. A visual acuity of 6/10 is required to read everything except medicine bottle labels with moderate fluency, but to read with near-normal fluency, 6/7.5 or 6/6 is required.

Contrast sensitivity loss has been shown to correlate with reading disability. Using Whittaker and Lovie-Kitchin's[53] contrast reserves of 4:1 for fluent reading, we can calculate the required contrast sensitivity to give a certain reading rate (see Appendix). If we assume the average contrast of newsprint to be 70%, the calculated required log contrast sensitivity to attain this would be 0.75. Leat and Woo[54] plotted Pelli-Robson contrast sensitivity against actual measured reading rate for magnified text and showed that a Pelli-Robson score of at least 1.05 would be required for fluent reading to be possible. These are measurements which are based on the maximum measured reading rates. There are many low vision observers who have the same contrast reserve who do not achieve reading rates as high, and this is presumably because of other factors, e.g., field or acuity restrictions. In the case of Leat and Woo's data, there were limitations of speed because of the fact that observers were using an optical low vision aid, which may limit reading speed itself and which also limits the acuity reserve that can be provided.

In a range of tasks, Rubin et al.[33] found that there was a significant increase in visual disability for people with visual acuity less than 6/12 or contrast sensitivity less than 1.7 on the Pelli-Robson chart. It must be noted that they took an arbitrary cut-off of 0.3 log units poorer than normal. This does not mean that all people with contrast sensitivity or visual acuity lower than this cut-off experienced visual disability. Their data, as presented, do not tell whether a different cut-off may have differentiated better between visual disability and no disability. Sultan et al.[73] presented data which showed that a reported visual disability for a number of daily living tasks is likely to occur if visual acuity is 6/18 or less. Housework, taking medications, and travelling was likely to be affected if visual acuity was 6/15 or worse. Their data are shown in Table 5.

TABLE 5.

Data from Sultan et al.[73] showing visual acuity limits for reported disability.

Task	Visual Acuity Resulting in Reported Disability
Shopping, telephone, preparing meals, money management	6/18 or less (no patient with visual acuity >6/18 reported disability)
Housework, taking medications, travelling	6/15 or less

Being able to drive is very important in North America, which is a very car-dependent society. Driving disability is usually a considerable social, employment, and economic disadvantage. In addition, with the aging of the baby boomer generation, there will be an increasing number of people who are used to driving and for whom loss of their driving license because of poor vision results in a serious disability. The driving standards among countries varies from 6/6 (Liberia) to 20/70 in some states of the U.S.[74] Even within the U.S., there are different standards. In Canada, the recommended standard for driving private cars is best visual acuity of 6/12 with a binocular horizontal visual field of 120° as measured with a III-3 Goldmann target,[75] and it is expected that more provinces will adopt this standard. The European Community standard is 6/12 with both eyes together and not more than 20° loss in the temporal visual field.[74] In Britain, the standard is still defined in terms of the number plate test, which has been shown to fail the same number of people as a Snellen visual acuity of 6/10.[76] In Australia, the standard also varies, between 6/12 and 6/18, in different states. There appears to be a trend toward relaxing the driving standards, particularly with respect to visual acuity. This is because a number of studies have shown that visual acuity is not strongly associated with driving record (number of crashes).[77,78]

Many countries have no visual field restriction (e.g., Belgium, Denmark, Greece) or no routine visual field screening (U.K.). Other countries specify that the visual field should be normal and the majority of those that do specify a field size do not specify what size of target should be used. The European Union Directive has specified that 120° is required, and it was expected that this would be incorporated into U.K. law in 1996.[79] The association between visual fields and driving performance has also been called into question, although this may be because of methodological problems in the studies.[80] Even though several studies have shown an association between visual field defects and driving or driving-related skills,[81–84] we still do not know what minimum visual field is required before driving becomes unsafe.[80] Loss of contrast sensitivity as measured with the Pelli-Robson chart is also correlated to driving performance,[82] but again we do not know at what reduction of contrast sensitivity driving becomes unsafe.

Although more than one-half of the states in the U.S. allow driving with the use of bioptic telescopes[85] as long as the visual field is intact, we will base this discussion on the current standards without a low vision device, which is consistent with the discussion above on reading and other tasks. This is consistent with most understandings of visual disability, meaning without the aid of devices.

Our final recommendations for disability, given the current state of knowledge, are shown in Table 6.

WHAT QUESTIONS REMAIN UNANSWERED?

In order to establish good definitions of visual impairment, we require good normal data, with means and standard deviations. It is surprising how little normative data are published, even on the routinely used measure of visual acuity. There is very little published data for visual fields. Without this, we cannot clearly define what constitutes a visual impairment. Data of visual fields plots as analyzed with a technique such as the Esterman grid would allow a visual field plot to be defined by one single figure and gives functional weighting to various parts of the field. We still know little about this weighting function, because presumably this is task-dependent. Most studies that have examined weightings have used mobility, but other ranges of tasks may produce different weightings. The use of suprathreshold screening techniques with computerized perimeters should be explored.

There is even less data on which we can base a decision of what minimum level of visual impairment is likely to give rise to a visual disability. There is some information on visual acuity, if we include theoretically calculated values and driving standards. For visual fields and contrast sensitivity, there are almost no data. We do not know what is the minimum extent of visual field loss before a visual disability is incurred. We do not even know what is the minimum field necessary for safe driving. It seems that current visual field standards (for legal blindness) were not derived from empirical data. However, we do know that identifying visual disability (low vision) in terms of constriction to a given angle of field (e.g., reduced to 20° as is currently the definition of legal blindness in the U.S. and Canada) would be inadequate. Murdoch et al.[4] show how this would exclude persons with considerable losses in functionally important parts of the visual field, e.g., the inferior field. One alternative would be to use descriptive categories such as used in the U.K., where field restrictions are defined as "considerable" or "moderate." This is obviously open to "considerable" interpretation by different practitioners. The current legal visual field standards for driving were also derived in an ad hoc manner and are also inadequate, so that many (often descriptive) caveats are required.[75, 79] Ideally we would like a more scientifically defensible definition which could be consistently and objectively applied to all people.

A recent approach is to examine the effect of visual impairment on quality of life. Instruments which attempt to measure quality of life include questions that reflect both perceived disability and handicap. These are only recently being introduced and used in the arena of low vision and results are still preliminary.[86] There are a few instruments which have been created or adapted specifically for use with people with reduced vision; for example, the new Visual Functioning Questionnaire.[87, 88] Older generic instruments are unlikely to be sensitive to the particular difficulties encountered by people with low vision. This approach may prove beneficial to further define what levels of visual loss result in disability and handicap, or the score from such a questionnaire could itself be used as a criterion for disability.

In the present discussion, we have described disability as a subjective measure only. However, objective measures of disability could be developed. For instance, well standardized methods for assessing reading, driving, or other real-world activities might play a role in objective disability assessment.

TABLE 6.
Recommended limits for low vision (visual impairment causing a disability).

Visual Measure	Suggested Limit for Disability
Visual acuity	less than 6/12
Contrast sensitivity (Pelli-Robson)	less than 1.05
Visual fields	120° with the III-3e target, based on the legal inability to drive alone. This is equivalent to 10 dB attenuation with the Humphrey and therefore demands a full horizontal field with the Humphrey, which can only measure out to 60°.

CONCLUSIONS AND RECOMMENDATIONS

Despite the fact that more data are required, we do think that the time is ripe for a re-evaluation of definitions. We suggest that low vision be defined as visual impairment sufficient to cause a disability. From the data presented above, it seems that the definition for visual disability should be <6/12. With 6/12 or better a person would still be eligible to drive in most countries and would be able to perform all daily living tasks and most reading tasks (although slowly). Once visual acuity drops below 6/12, driving, reading, and some daily living tasks become compromised. Thus, there is a gap between visual impairment and low vision sufficient to cause disability. In terms of visual acuity, <6/7.5 would be classified as a visual impairment, but disability is not likely to occur until visual acuity has further decreased to <6/12. An example here may clarify this point. Take a woman with early dry age-related macular degeneration, which reduces her visual acuity to 6/9. She has a disorder (the macular changes). She also has a measurable visual impairment (the visual acuity is below the normal range). However, legally she is still allowed to drive and is likely to have few, if any, functional limitations (disabilities) in normal daily life. She does not have a disability and does not yet require rehabilitation; she does not have low vision at this time. However, if her visual acuity subsequently drops to 6/15, she will probably experience difficulty with reading regular print with a regular reading addition and will no longer be able to drive. She now has a disability which, depending on how much she values reading and driving, may lead to a handicap. Rehabilitation seeks to intervene by reducing the disability (providing low vision aids), thus reducing the handicap. The reason for this gap between impairment and disability is because there is a reserve of capacity.[2] Most tasks have evolved based on the human factor of normal vision, so that the normally sighted person is not functioning at his/her visual limit. There is some "forgiveness" in the system, allowing some loss of visual function before losing the ability to perform tasks.

In terms of Pelli-Robson contrast sensitivity, a visual impairment would be a contrast sensitivity of less than 1.5, but the range of values which may result in disability is <1.05 to <0.75. We have very little information on what visual field loss results in a disability. If we allow the loss of a driving license to be considered a disability, then a visual field of less than 120° (III-3e) would be classified as a visual disability. From Williams' data,[45] this means that 2.5% of normally sighted adults in the 60- to 69-year-old group would be considered disabled, although they would not be considered visually impaired until the visual field has constricted to less than 109°, i.e., visual disability occurs before visual impairment as visual field is gradually lost! This does beg the question as to whether 120° is too stringent a criterion for driving or whether 120° with the III-4e, rather than the III-3e target, would be more appropriate. Then we would not have the anomaly that 2.5% of elderly people with vision in the normal range would be ineligible to drive. These recommendations for visual field measurements are interim recommendations.

What will be the impact of redefining low vision in this way? There would be an impact in areas of research and service provision. Studies in low vision would be encouraged to include more people with mild vision loss and with mild disability. It would (legitimately) make visual impairment and disability appear to be a more prevalent and pressing problem in many countries. According to statistics from Tielsch et al.,[14] changing the criterion for low vision (including legal blindness) from <6/18 to <6/12 would change the age-adjusted prevalence rates from 1.46 to 2.96% for whites and 3.2 to 5.69% for blacks. Across all age groups and in each age group it would result in a 1.8 to 2× increase in the prevalence of low vision for both whites and blacks. The Salisbury Eye Evaluation Study figures[15] are in agreement and show that changing the criterion would result in an increase in prevalence of visual impairment from 2.42 to 4.52% in the age group 65 to 84 years. This may have less financial impact in the U.S., because the Social Security Administration already uses <6/12 as their definition, but it may have a considerable impact in some other countries. Another consideration is the impact on monitoring population trends if there is a change in criteria. One way to avoid this difficulty is to record data in actual visual acuity terms or in more than one category of visual acuity, as in the Salisbury Eye Evaluation and Tielsch studies. Then trends can still be analyzed.

The positive advantages of a universally accepted standard would be more consistency in studies performed in different locations, more consistency in the availability of services for those who require them, and intervention before a visual disability becomes a major handicap.

We are aware that there is a paucity of information on which to base these recommendations. More research is required to increase our understanding in this area. We have summarized recommendations of what level of visual function should be considered likely to give rise to a disability (Table 6), but these may have to be revised as further information becomes available. However, we feel that people with a visual impairment of this order would benefit from access to rehabilitation services in order to maintain their independence and prevent visual handicap. Additionally, we would recommend that any person with a measurable visual impairment, according to the criteria presented here, who also reports a visual disability, should also have access to these services. Interestingly, this is similar to the AHCPR recommendations for cataract surgery.[89] This says that surgery is indicated when "the cataract reduces visual function to a level that interferes with everyday activities of the patient. . . " This guideline is applied for patients with visual acuity of ≤6/15 (20/50) but also for those with visual acuity of ≥6/12 (20/40). The final criterion is the disability or symptoms that the patient is experiencing because of the presence of cataract. Surgery is not indicated solely because of the presence of cataract. This would appear to be analogous to the present situation, in which we are suggesting that rehabilitative services should be available when there is both a reported disability (currently a subjective criterion) and a measurable visual impairment (objective criterion). As mentioned above, standardized objective measures for disability could be developed for future use in order to substantiate and quantify subjective reports of disability.

The visual acuity, visual field, and contrast sensitivity criteria for visual disability are independent, i.e., a person is classified if they fail any, not all, of the criteria. Consideration should be given to the person whose vision is impaired in more than one modality, e.g., poor visual acuity and contrast sensitivity, which does not quite reach the criterion for disability in either. Yet this person may find themselves to be quite visually disabled because of the additive or interactive effects of each modality. The total disability may be greater than that caused by the loss of visual acuity or contrast sensitivity alone. Currently, we have no knowledge of how the effects may combine, e.g., additively, multiplicatively. A method for combining the disabling effects of visual acuity and visual fields was suggested by the National Research Council[40] by calculating the product of the percentage visual efficiency in each modality. However, our recommendation of allowing any person with a visual impairment access to rehabilitation, if they complain of disability, would help to alleviate this problem.

Adopting this less conservative definition would allow people's independence to be prolonged, thus reducing the drain on other services. It would also allow intervention to begin at the early stages of a visual disability. This may be better psychologically, allow gradual adaptation to the use of low vision aids, and prevent a "gap" during which there is disability but no intervention, resulting in the build-up of numerous areas of disability and handicap.

APPENDIX
Calculation of acuity required to read print sizes

1 M print is defined as each letter subtending 5 min arc at 1 m, 0.5 M subtends 5 min arc at 0.5 m, and so on. The equivalent Snellen letters would have detail of 1 min of arc.

The definition of the Snellen fraction =

$$\frac{\text{the test distance}}{\text{the distance at which the smallest letter read subtends } 5'}$$

Therefore, 0.8 M print read at 0.333 m has an equivalent Snellen fraction of

$$\frac{0.333}{0.8} = 0.4166$$

To convert to a 6 m Snellen acuity =

$$\frac{0.4166 \times 6}{6} = \frac{6}{2.4 \times 6} = \frac{6}{14.4}$$

To give a 1.5× reserve of acuity, we require acuity 1.5× better visual acuity, i.e.,

$$\frac{6}{14.4 \div 1.5}$$

Calculation of contrast sensitivity reserve

Assuming print contrast = 70% (0.7) and contrast reserve required = 4:1.

Contrast threshold required to give this reserve =

$$\frac{0.7}{4} = 0.175$$

$$\text{Contrast sensitivity} = \frac{1}{\text{contrast threshold}} = 5.714$$

Log contrast sensitivity = 0.757

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REFERENCES

1. World Health Organization. International Classification of Impairments, Disabilities and Handicaps: A Manual of Classification Relating to the Consequences of Disease. Geneva: World Health Organization, 1980.
2. Colenbrander A. What's in a name: more people are blinded by definition than by any other cause. J Videol 1996;1:13–20.
3. World Health Organization Study Group on the Prevention of Blindness. World Health Organization Technical Report Series. Geneva: World Health Organization, 1972:518.
4. Murdoch IE, Jones BR, Cousens S, Liman I, Babalola OE, Dauda J, Abiose A. Visual field constriction as a cause of blindness or visual impairment. Bull WHO 1997;75:141–6.
5. BD8 Form. London: Her Majesty's Stationery Office, 1991.
6. Fielder AR, Best AB, Bax MCO. The Management of Visual Impairment in Childhood. London: Mac Keith Press (Cambridge University Press), 1993.
7. Ford M, Heshel T. The In Touch Handbook. London: Broadcasting Support Services for BBC Radio 4, 1993.
8. Grey RH, Burns-Cox CJ, Hughes A. Blind and partial sight registration in Avon. Br J Ophthalmol 1989;73:88–94.
9. Bailey IL, Lovie JE. New design principles for visual acuity letter charts. Am J Optom Physiol Opt 1976;53:740–5.
10. Bailey IL. Designation of visual acuity in logarithmic units. Optom Mon 1980;71:53–8.
11. Bier N. Correction of Subnormal Vision. London: Butterworths, 1970.
12. Kirchner C. Data on Blindness and Visual Impairment in the U.S.: A Resource Manual on Social Demographic Characteristics, Education, Employment and Income, and Service Delivery. New York: American Foundation for the Blind, 1988.
13. Ford M, Heshel T. In Touch 1995–1996 Handbook. London: Public Broadcasting Support Services, 1995.
14. Tielsch JM, Javitt JC, Coleman A, Katz J, Sommer A. The prevalence of blindness and visual impairment among nursing home residents in Baltimore. N Engl J Med 1995;332:1205–9.
15. Rubin GS, West SK, Munoz B, Bandeen-Roche K, Zeger S, Schein O, Fried LP. A comprehensive assessment of visual impairment in a population of older Americans. The SEE Study. Salisbury Eye Evaluation Project. Invest Ophthalmol Vis Sci 1997;38:557–68.
16. National Advisory Eye Council. Vision Research: A National Plan: 1994–1998. Washington, DC: U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, 1993:305–21.
17. Mehr EB, Fried AN. Low Vision Care. Chicago: Professional Press, 1975:1.
18. Robbins HG. The low vision patient of tomorrow. Aust J Optom 1978;61:54–64.
19. Faye EE. Clinical Low Vision 2nd ed. Boston: Little, Brown, 1984:6.
20. Nowakowski RW. Primary Low Vision Care. Norwalk, CT: Appleton & Lange, 1994:2.
21. Leat SJ, Rumney NJ. The experience of a university-based low vision clinic. Ophthalmic Physiol Opt 1990;10:8–15.
22. Robbins HG. Low vision care for the over 80's. Aust J Optom 1981; 64:243–51.
23. Humphry RC, Thompson GM. Low vision aids—evaluation in a general eye department. Trans Ophthalmol Soc UK 1986;105: 296–303.
24. Yap M, Cho J, Woo G. A survey of low vision patients in Hong Kong. Clin Exp Optom 1990;73:19–22.
25. Kleen SR, Levoy RJ. Low vision care: correlation of patient age, visual goals, and aids prescribed. Am J Optom Physiol Opt 1981;58:200–5.
26. Office of Populations Censuses and Surveys. The Prevalence of Disability among Adults. London: Her Majesty's Stationery Office, 1993.
27. Statistics Canada. Census of the Population: Disability Question Guide for Respondents. Ottawa: Ministry of Supply and Services, 1986.
28. The Lighthouse, Inc. The Lighthouse National Survey on Vision Loss: The Experience, Attitudes and Knowledge of Middle-Aged and Older Americans. New York: The Lighthouse, Inc., 1995.
29. Tielsch JM, Sommer A, Witt K, Katz J, Royall RM. Blindness and visual impairment in an American urban population. The Baltimore Eye Survey. Arch Ophthalmol 1990;108:286–90.
30. Klein R, Klein BE, Linton KL, De Mets DL. The Beaver Dam Eye Study: visual acuity. Ophthalmology (Rochester) 1991;98:1310–5.

31. Ross JE, Bron AJ, Clarke DD. Contrast sensitivity and visual disability in chronic simple glaucoma. Br J Ophthalmol 1984;68:821–7.
32. Elliott DB, Hurst MA, Weatherhill J. Comparing clinical tests of visual function with the patient's perceived visual disability. Eye 1990;4:712–7.
33. Rubin GS, Roche KB, Prasada-Rao P, Fried LP. Visual impairment and disability in older adults. Optom Vis Sci 1994;71:750–60.
34. Elliott DB, Yang KC, Whitaker D. Visual acuity changes throughout adulthood in normal, healthy eyes: seeing beyond 6/6. Optom Vis Sci 1995;72:186–91.
35. Ehlers H. Clinical testing of visual acuity. Arch Ophthalmol 1953; 49:431–4.
36. Wild JM, Hussey MK. Some statistical concepts in the analysis of vision and visual acuity. Ophthalmic Physiol Opt 1985;5:63–71.
37. Brown B, Lovie-Kitchin J. Repeated visual acuity measurement: establishing the patient's own criterion for change. Optom Vis Sci 1993;70:45–53.
38. Frisen L, Frisen M. How good is normal visual acuity?. A study of letter acuity thresholds as a function of age. von Graefes Arch Klin Exp Ophthalmol 1981;215:149–57.
39. Elliott DB, Sheridan M. The use of accurate visual acuity measurements in clinical anti-cataract formulation trials. Ophthalmic Physiol Opt 1988;8:397–401.
40. National Research Council, Committee on Vision. Measurement of Visual Field and Visual Acuity for Disability Determination. Washington, DC: National Academic Press, 1994.
41. Reeves BC, Wood JM, Hill AR. Reliability of high- and low-contrast letter charts. Ophthalmic Physiol Opt 1993;13:17–26.
42. Ariyasu RG, Lee PP, Linton KP, LaBree LD, Azen SP, Siu AL. Sensitivity, specificity, and predictive values of screening tests for eye conditions in a clinic-based population. Ophthalmology (Rochester) 1996;103:1751–60.
43. Flammer J, Drance SM, Augustiny L, Funkhouser A. Quantification of glaucomatous visual field defects with automated perimetry. Invest Ophthalmol Vis Sci 1985;26:176–81.
44. David Henson, personal communication.
45. Williams TD. Goldmann visual field norms for age groups 25 to 75 years: I-1, III-3 and III-4 targets. Can J Optom 1996;58:170–5.
46. Heijl A, Lindgren A, Lindgren G. Test-retest variability in glaucomatous visual fields. Am J Ophthalmol 1989;108:130–5.
47. Esterman B. Functional scoring of the binocular field. Ophthalmology (Rochester) 1982;89:1226–34.
48. Lovie-Kitchin J, Mainstone J, Robinson J, Brown B. What areas of the visual field are most important for mobility in low vision patients? Clin Vis Sci 1990;5:249–63.
49. Drasdo N, Peaston WC. Sampling systems for visual field assessment and computerized perimetry. Br J Ophthalmol 1980;64:705–12.
50. Verriest G. Percentage impairment by visual field defects In: Heijl A, Greve E, eds. Seventh International Visual Field Symposium, Amsterdam, September 1986. Dordrecht, The Netherlands: Dr. W. Junk Publishers, 1987.
51. Arditi A. The volume visual field: a basis for functional perimetry. Clin Vis Sci 1988;3:173–83.
52. Rubin GS, Legge GE. Psychophysics of reading. VI—The role of contrast in low vision. Vision Res 1989;29:79–91.
53. Whittaker SG, Lovie-Kitchin J. Visual requirements for reading. Optom Vis Sci 1993;70:54–65.
54. Leat SJ, Woo GC. The validity of current clinical tests of contrast sensitivity and their ability to predict reading speed in low vision. Eye 1997;11:893–9.
55. Marron JA, Bailey IL. Visual factors and orientation-mobility performance. Am J Optom Physiol Opt 1982;59:413–26.
56. Owsley C, Sloane ME. Contrast sensitivity, acuity, and the perception of "real-world" targets. Br J Ophthalmol 1987;71:791–6.
57. Lennerstrand G, Ahlstrom CO. Contrast sensitivity in macular degeneration and the relation to subjective visual impairment. Acta Ophthalmol (Kbh) 1989;67:225–33.
58. Elliott DB, Whitaker D. How useful are contrast sensitivity charts in optometric practice? Case reports. Optom Vis Sci 1992;69:378–85.
59. Leguire LE. Do letter charts measure contrast sensitivity? Clin Vis Sci 1991;6:391–400.
60. Elliott DB, Sanderson K, Conkey A. The reliability of the Pelli-Robson contrast sensitivity chart. Ophthalmic Physiol Opt 1990;10: 21–4.
61. Elliott DB, Bullimore MA. Assessing the reliability, discriminative ability, and validity of disability glare tests. Invest Ophthalmol Vis Sci 1993;34:108–19.
62. Beck RW, Diehl L, Cleary PA, and the Optic Neuritis Study Group. The Pelli-Robson letter chart: normative data for young adults. Clin Vis Sci 1993;8:207–10.
63. Brown B, Lovie-Kitchin JE. High and low contrast acuity and clinical contrast sensitivity tested in a normal population. Optom Vis Sci 1989;66:467–73.
64. Regan D. Low-contrast letter charts and sinewave grating tests in ophthalmological and neurological disorders. Clin Vis Sci 1988;2: 235–50.
65. Pardhan S. A comparison of binocular summation in young and older patients. Curr Eye Res 1996;15:315–9.
66. Pardhan S. Binocular performance in patients with unilateral cataract using the Regan test: binocular summation and inhibition with low-contrast charts. Eye 1993;7:59–62.
67. Tobin MJ, Hill EW. The aging process and visual disability investigating change. New Beacon LXXIV 1990;881:381–5.
68. Elliott DB, Trukolo-Ilic M, Strong JG, Pace R, Plotkin A, Bevers P. Demographic characteristics of the vision-disabled elderly. Invest Ophthalmol Vis Sci 1997;38:2566–75.
69. Hall A, Sacks SZ, Dornbusch H, Raasch T. A preliminary study to evaluate patient services in a low vision clinic. J Vision Rehab 1987; 1:7–25.
70. Mills RP, Drance SM. Esterman disability rating in severe glaucoma. Ophthalmology (Rochester) 1986;93:371–8.
71. De Marco LM, Massof RW. Distributions of print sizes in U.S. newspapers. J Vis Impairment Blind 1997;91:9–13.
72. Bailey IL, Lovie JE. The design and use of a new near-vision chart. Am J Optom Physiol Opt 1980;57:378–87.
73. Sultan MB, Meehan RH, Castor C. The impact of ocular disease on the instrumental activities of daily living. Invest Ophthalmol Vis Sci 1997;38:S710.
74. Charman WN. Visual standards for driving. Ophthalmic Physiol Opt 1985;5:211–20.
75. Canadian Medical Association. Physician's Guide to Driver Examination. 5th ed. Ottawa: Canadian Medical Association, 1991.
76. Drasdo N, Haggerty CM. A comparison of the British number plate and Snellen vision tests for car drivers. Ophthalmic Physiol Opt 1981;1:39–54.
77. Gresset JA, Meyer FM. Risk of accidents among elderly car drivers with visual acuity equal to 6/12 or 6/15 and lack of binocular vision. Ophthalmic Physiol Opt 1994;14:33–7.
78. Shipp MD, Penchansky R. Vision testing and the elderly driver: is there a problem meriting policy change? J Am Optom Assoc 1995; 66:343–51.
79. Munton G. Vision. In: Taylor JF, ed. Medical Aspects of Fitness to Drive: A Guide for Medical Practitioners. London: Medical Commission on Accident Prevention, 1995:118–32.
80. North RV. The relationship between the extent of visual field and

driving performance—a review. Ophthalmic Physiol Opt 1985;5: 205–10.
81. Johnson CA, Keltner JL. Incidence of visual field loss in 20,000 eyes and its relationship to driving performance. Arch Ophthalmol 1983; 101:371–5.
82. Ball K, Owsley C, Sloane ME, Roenker DL, Bruni JR. Visual attention problems as a predictor of vehicle crashes in older drivers. Invest Ophthalmol Vis Sci 1993;34:3110–23.
83. Wood JM, Troutbeck R. Effect of restriction of the binocular visual field on driving performance. Ophthalmic Physiol Opt 1992;12:291–8.
84. Wood JM, Troutbeck R. Elderly drivers and simulated visual impairment. Optom Vis Sci 1995;72:115–24.
85. Appel SD, Brilliant RL, Reich LN. Driving with visual impairment: facts and issues. J Vision Rehab 1990;4:19–31.
86. Raasch TW, Leat SJ, Kleinstein RN, Bullimore MA, Cutter GR. Evaluating the value of low-vision services. J Am Optom Assoc 1997; 68:287–95.
87. Mangione CM, Lee PP, Berry SH, Hays RD, Janz NK, Klein R, Owsley C. Development of a questionnaire for the assessment of vision function. Invest Ophthalmol Vis Sci 1995;36:S428.
88. Bullimore MA, Raasch TW, Cutter GC, Kleinstein RN, Leat SJ. Quality of life assessment in a low vision population. Invest Ophthalmol Vis Sci 1997;38:S710.
89. Cataract Management Guideline Panel. Cataract in Adults: Management of Functional Impairment. Rockville, MD: U.S. Department of Health and Human Services, Public Health Service, Agency for Health Care Policy and Research,1993.

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