Technology Assessment Program
Office of Patient Care Services

VATAP SHORT REPORT: *VISUAL FIELD TESTING IN VA COMPENSATION AND PENSION EXAMINATIONS*

March 2003

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8. Description of the health technology?	√		
How?			
9. Details on sources of information?	√		
10. Information on selection of material for assessment?	√		
11. Information on basis for interpretation of selected data?	√		
What?			
12. Results of assessment clearly presented?	√		
13. Interpretation of the assessment results included?	√		
What Then?			
14. Findings of the assessment discussed?	√		
15. Medico-legal implications considered?	√		
16. Conclusions from assessment clearly stated?	√		
17. Suggestions for further actions?		√	

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VA TECHNOLOGY ASSESSMENT PROGRAM

SHORT REPORT

Visual field testing in VA compensation and pension examinations

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Executive Summary

The Appendix to this report includes figures and tables with important information that will be helpful in clarifying the text and in further documenting VATAP's review methods.

- **The visual field** is all of the three-dimensional space that one eye can see in any given instant. **Perimetry** (from the Greek *perimetros,* circumference) is the study or testing of the visual field, and the devices it uses are **perimeters**.

- The two major types of perimeters are manual and automated. The Goldmann perimeter is the manual device for testing virtually the entire visual field, and the Humphrey Field Analyzer was the automated perimeter specified for this report. The Humphrey and other automated perimeters came into widespread use in the 1980s.

- This report categorizes research comparisons primarily as manual versus automated perimeters. A secondary category of static (Humphrey) versus kinetic (Goldmann) testing strategies also contributes to the review. Static and kinetic refer to behavior of the stimulus light during testing.

- **Review questions:** This VATAP report responds to questions raised within the Veterans Health Administration (VHA) and by veterans service organizations (VSOs) regarding the roles of Goldmann and Humphrey perimeters in the vision component of VA compensation and pension (C&P) exams:

  1. Which perimeter (Goldmann or Humphrey) is the "standard of practice"? What are their respective roles?

  2. How would visual field defect rating indices applicable to either perimeter assist the Veterans Benefit Administration (VBA) in evaluating disability and handicap?

  3. Do perimeters give reliable results? Is the variation among Goldmann tests sufficient in magnitude that veterans undergoing testing by different operators (perimetrists) cannot rely on equivalent examinations?

- The report is not intended to guide device operation or selection of one device from among several for purchase, nor is it intended as a comprehensive treatise on perimetry. This report restricts its scope to the assessment issues outlined above, which are approached through the published clinical research literature.

- **WHO convention for terms: disorder, impairment, disability, and handicap.** VATAP adheres to the usage convention recommended by the World Health Organization (WHO).

  Disorder and *impairment* are conditions of organs. *Disability* and *handicap* are conditions of the individual, referring to skills and abilities, and to social and economic consequences, respectively. Thus, visual field testing assesses impairment, while a compensation and pension decision refers to disability and handicap.

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- **Goldmann and Humphrey perimeters: relative roles?** VATAP approached the assessment of relative roles for the perimeters by searching for studies directly comparing Goldmann with Humphrey (or other automated) perimeters. The bulk of such studies addressed diagnostic accuracy for visual field defects in glaucoma.

  Glaucoma comprises a group of ocular disorders characterized by pressure-related damage to the optic nerve. It is the leading cause of blindness, world-wide. Other research comparisons generally evaluated diagnostic accuracy in relatively uncommon diseases and enrolled low enough numbers of subjects to make generalizing their findings to VHA unreliable.

  Only two of the published glaucoma studies approximated established methods standards for evaluations of diagnostic test accuracy, and thus only these two were strictly eligible for inclusion in this report. Both found that automated perimeters identify visual field defects earlier in the course of disease. Rigorous methods and concurrence of results make the common finding of these studies credible.

  Other studies are cited in the text only to the extent that they clarify understanding of complex perimetry issues, not as evidence *per se* for the review questions.

- **Complementary roles for Goldmann and Humphrey perimeters:** While tracking the literature through time suggests that automated perimeters like the Humphrey are replacing the manual Goldmann, no generally acknowledged standard of practice can be inferred from published research. During the transition period, a number of factors argue for retaining availability of both perimeters to clinicians. Complementary roles include:
  - Manual and automated perimeters typically measure different proportions of the entire volume of the normal visual field; the location within the field that is of primary interest in a particular clinical situation should guide selection of perimeter;
  - Earlier identification of glaucoma defects by automated perimeters;
  - VA C&P exam populations are heterogeneous, and population subgroups align with differences in the patient groups for which each perimeter is most suitable;
  - The two perimeters have different requirements for training, operation, and results interpretation.

- **Defining visual disability** is a problematic issue on which there is little consensus and even fewer data to associate visual field defects with specific difficulties in activities of daily living other than driving or with employment disadvantage. What little consensus does exist argues for *functional* rather than anatomic indices to indicate the degree of visual field defects, for multiple measures of disability, and for individual assessments of performance on specific vision-dependent tasks.

  While the optimal method for determination of visual disability is an unresolved issue, classifying functional deficits (skills and abilities) with a correspondingly functional rating index for the visual field makes intuitive sense.

  The Esterman functional index can be applied to results from both manual and automated perimeters, is available as software on some automated devices, and has been recommended by the American Medical Association (AMA) since 1984. VBA currently uses an anatomic index corresponding with older (1958) AMA recommendations for the evaluation of permanent visual impairment.

  Evaluation of visual disability and benefits eligibility within the United Kingdom's National Health Service concurs with a functional basis for rating the residual visual field.

- **Reliability:** Reliability issues are different for the two types of perimeter; implications of reliability problems for diagnostic performance have yet to be completely defined by research for either.

  Manual perimetry is widely considered a technically demanding task for the *perimetrist.* While a few exploratory studies have identified operator-dependent variables that potentially may influence test results, VATAP literature database searches did not identify formal inter-rater reliability studies for the Goldmann perimeter.

  Automated perimeters, including the Humphrey, generally include *patient* reliability indicators, most commonly gaze fixation (attention) losses in their software and results prints, but quantification of impact on diagnostic performance remains incomplete.

Background

Please consult the APPENDIX to this report for figures and tables clarifying issues in perimetry and further documenting VATAP's review methods.

The visual field is all the space that one eye can see at any given instant. **Perimetry** is the study or testing of the visual field, and **perimeters** are the devices used for testing.

While the visual field is most accurately represented in three dimensions ("the island of vision"), the conventions of perimetry often refer to it as two-dimensional: conducting a visual field test is "mapping the field", and results of testing are presented in two dimensions.

Field defects due to trauma, brain tumors, stroke, or to other diseases anywhere along the visual pathway from eye to cerebral visual cortex include indentations of the island base and blind or blurred spots elsewhere within the space. Defects decrease the functional volume of the field.

Perimetry quantifies problems in paracentral and peripheral vision. Although poor vision is more frequently quantified by Snellen acuity measurement, visual field defects also can result in significant impairment of vision; some definitions of low vision (Table 4, Appendix) reference perimetry results as well as acuity.

Perimetry is a complex area of study and clinical practice, offering many options for the conduct of tests (Henson, 2000). As a test of perception, it also is subjective and responsive to normal variations in the physiology of vision (Esterman, 1986; Parrish, 1984). The complexity includes a great many devices (perimeters) and multiple incremental technical refinements specific to each. The main perimeter types are manual and automated. While the Goldmann perimeter is the only manual device capable of testing virtually the entire visual field (Figure 2, Appendix), other manual devices, e.g., the tangent screen for testing the central field, are available.

The Humphrey Field Analyzer perimeter was the automated device specified in the request for this report, but many others (Figure 1, Appendix) are available. Figure 1 provides a sampling of the device variety and technical refinements represented in the literature, along with synonyms that will be used throughout the report, while Figure 2 indicates the extent of the normal visual field that is accessible to testing for the major types of perimeter.

Goldmann (manual or kinetic) perimetry is a long-standing reference (Werner, 1999; Horton, 2001; AMA, 1958), and is specified in legislation defining the vision component of VA compensation and pension (C&P) examinations.

The Social Security Administration (SSA) also uses Goldmann results for legal blindness classification. However, SSA acknowledges the growing role of automated perimetry in defining visual impairment (American Council of the Blind, 2002).

Henson (2000) provides a rationale for the variety of devices and testing strategies: "*To the newcomer, one of the most confusing aspects of*

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visual field investigation must surely be the overwhelming number of different ways in which the visual field may be examined. Is it really necessary to have all these different strategies? Cannot the perimetric community decide which is best and then do away with the rest?…

The short answer to these questions is 'No'. Different visual field strategies are necessary because the objectives of a visual field examination vary from one situation to another…"

Adding to the complexity, major types of devices are not mutually exclusive: some perimeters, including those of interest to this report, are capable of both static and kinetic testing, represented by within-device test strategy comparisons in the literature (Table 2, Appendix).

Policy context for the review

This VA Technology Assessment Program (VATAP) report responds to questions raised within the Veterans Health Administration (VHA) and by veterans service organizations (VSOs) regarding visual fields testing.

Within the confines of legislation requiring the Goldmann test, the relative roles of Goldmann and Humphrey perimeters in C&P examinations is the primary concern.

This report is intended to support VHA policy regarding perimeter use according to evidence from the best available clinical research. Its purpose is not to guide operation of perimeters, selection of specific models for purchase, or to be a comprehensive perimetry resource.

Definitions

VATAP will use the terms "disorder", "impairment", "disability", and "handicap" as proposed in the World Health Organization (WHO) *International Classification of Impairments, Disabilities, and Handicaps* (1980) and encapsulated in Figure 3 (Appendix).

Briefly, under the WHO usage convention, *disorder* indicates any deviation from normal structure or physiology, and *impairment* the loss or departure from normal function; both are conditions of organs. *Disability* and *handicap*, in contrast, are conditions of the individual in his or her environment: disability refers to changes in abilities and skills; handicap to social and economic consequences of these changes.

WHO definitions distinguish conditions of organs and body systems (parts of the individual; the anatomical or medical perspective) from those of entire, functioning individuals in social and economic contexts. Colenbrander (1996) and Leat (1999) convincingly advocate this nomenclature as the most useful approach to rehabilitation discussions and benefits determination.

Visual acuity and visual fields measurements are indicators of impairment and do not extrapolate directly or inevitably to disability or handicap (Colenbrander, 1992; 1996). Wright (1997), reviewing the literature as background to a survey study of visual disability and employment, notes that measures of impairment do not accurately predict the ways in which an individual uses vision. Parrish (1997), studying visual function and quality of life among glaucoma patients, comes to the same conclusion.

In the context of WHO definitions, secondary prevention, therapy, and rehabilitation influence the flexible links among disorder, impairment, disability, and handicap, with the uniform goal that a given disorder results in the least possible handicap (Colenbrander, 1992; 1996).

The vision component of C&P exams by VHA physicians documents impairment. An assessment by VBA of the extent to which visual impairment leads to disability and handicap for a particular individual will require additional information about that veteran's functioning in daily life and employment.

Assessment issues and questions

Reflecting VHA and VSO concerns, the questions that this report will address fall into three major categories: perimeters; reliability of testing; and disability/handicap evaluation. Consistency in numbering the three primary review questions is maintained throughout the report:

1. **What is the standard of practice for perimetry?**
   A. Have automated perimeters, specifically the Humphrey Field Analyzer, replaced the Goldmann perimeter as the standard of clinical practice for visual field testing?
   B. Are Goldmann and Humphrey visual field tests complementary, or are they essentially comparable?

2. **How would visual field defect rating indices applicable to either perimeter assist VBA in evaluating disability and handicap?**

3. **Are perimetry results reliable?** C&P exams must be fair and consistent. Do perimeters give reliable results? Specifically, is the variation among Goldmann tests of sufficient magnitude that veterans undergoing testing by different operators (perimetrists) cannot rely on equivalent examinations?

Assessment Methods

Search strategy

VATAP conducted Dialog® OneSearches of MEDLINE®, EMBASE®, Current Contents®, BIOSIS®, and SciSearch® for the years 1980 to February 2002 using a range of descriptors and free text words and phrases: Humphrey? (? indicates truncation) adjacent to Perimetr? Goldmann? adjacent to Perimetr? Additional terms for the concepts of diagnostic techniques for ophthalmology and diagnosis of visual field defects were used.

Another approach searched for articles containing words for perimetry and a list of terms indicating predictive values, sensitivity and specificity, along with comparative studies and/or precision, predictability, and reproducibility. These results were limited to English language and adult, middle age, and the terms for aged and elderly humans.

Article selection criteria

VATAP initially screened search printouts with abstracts for citations relevant to the three major issues to be addressed by this report. Articles lacking an analytic component were excluded, as were those reporting opinion that did not illuminate review issues.

VATAP then obtained full-text copies of selected articles and reviewed them in depth according to the following criteria (numbers correspond to those of the three main review issues outlined above).

1. One useful indicator of a standard of practice is supplied by consensus statements or practice guidelines generated by national professional organizations. In their absence, comparisons of automated static (Humphrey or other) perimetry to Goldmann manual kinetic perimetry facilitate analysis of the most appropriate clinical application of devices. Quality criteria for comparative (in this context, diagnostic accuracy) studies include (Mulrow, 1989):

   - patients comparable to VA C&P exam populations;
   - observers blinded to other test results;
   - performance of perimeter of interest compared to the "diagnostic gold standard", to other clinical disease criteria, or to follow up sufficient to confirm the presence or absence of disease.

2. Correlational or multi-variate studies of visual field disability ratings with independently determined levels of disability or handicap; or interventional studies, which artificially restrict visual fields and then test performance of vision-dependent tasks.

3. Inter-rater reliability studies: replicate perimetry studies (by different operators) of the same patients, using the same device and technique, are demonstrated to produce consistent results over periods of time in which the patients' conditions are expected to remain stable.

Finally, VATAP reviewed the reference lists of initially retrieved articles to identify additional studies relevant to the major assessment issues. Full-text articles were obtained and subjected to the same review criteria.

INAHTA query
In the final component of information retrieval, VATAP queried colleague agencies in the International Network of Agencies for Health Technology Assessment (INAHTA) via electronic mail regarding policies and practices for the determination of visual disability in the health care systems represented within INAHTA.

Results

Overall
VATAP searches yielded more than five hundred citations. End reference lists enhanced this number greatly. Ultimately, VATAP obtained and reviewed in detail 91 full text articles from searches and end references as relevant to review questions. Reviewed studies represent analytic research, while descriptive research and unsubstantiated opinion were excluded. Editorials providing insights on the review questions may be cited below, but do not constitute valid "evidence" for the questions. Included studies are abstracted in Tables 1 to 4 (Appendix). VATAP definitively excluded as "invisible" for the purposes of the report only articles contributing neither data nor insight to the review questions or to an understanding of underlying issues in perimetry

More specifically, exclusion of comparative studies was based on:

- Comparison not relevant to VHA review questions (e.g., one software program to another for the same automated perimeter);
- Population not relevant to general C&P exam population (e.g., all testing subjects taking the same drug);
- Failure to meet methods standards noted above for diagnostic test accuracy evaluations;
- Incomplete or uninterpretable reporting.

One reviewer (KF) selected, read, analyzed, and abstracted all studies. Other contributors and reviewers are listed on page 16.

In overview, VATAP found that the perimetry literature represents many divergent lines of enquiry, inconclusive findings, and a great deal of opinion, much of all of these irrelevant or tangential to the issues initiating this report. If the literature has an overall direction it is toward documenting technical development of devices rather than addressing specific clinical or policy questions relevant to VHA.

Tables 1 and 2 (Appendix) present frequency of study types within categories according to major assessment issues. These tables provide an overview of the scarcity of directly relevant research available to respond to the assessment questions.

Results, Assessment question #1:
A. Standard for clinical practice

Published studies do not directly address VHA's information needs for this issue: VATAP searches failed to identify consensus statements from professional organizations specifying the standard of practice for perimetry in general or for any diagnoses. Other indicators of a defined standard of practice are likewise unpublished.

In the absence of direct information on standard of practice, tracking the literature through time allows estimation of trends in clinical practice. However, this approach is able only to approximate a response to VA regarding a standard of practice.

Many of the studies cited in the "timeline" below are comparisons that are further detailed in Table 3 (Appendix):

1970s: early development and initial diffusion of automated perimeters
In a series of 2000 glaucoma field evaluations, Morin (1979) performed both static and kinetic testing on the same instrument, the Tübinger "Oculus", an early automated perimeter. Since Morin's criteria for patient participation included correspondence of static and kinetic fields, his

detailed enumeration of the apparently minor differences between static and kinetic results on the same device provides little enlightenment for VA's assessment questions regarding the roles of other devices. However, this large series does indicate that static and kinetic results will often correspond.

Wilensky (editorial; 1989) reported his experience: it was uncommon up to the mid-1970s for patients to report to a glaucoma specialist with good quantitative visual field results from the referring ophthalmologist. Since then, training office staff to operate an automated perimeter had changed the situation appreciably.

1980s: wider diffusion of automated perimeters

Comparative studies published during the period in which automated perimeters became widely available (Bobrow, 1982; Beck, 1985; Batko, 1983; Hart, 1983) were conducted explicitly to document the extent to which automated perimeters approximated Goldmann results, supporting the conclusion that the Goldmann perimeter remained the standard at that time.

Bobrow (1982) summarizes what may have been prevailing views at that time: *"An instrument that sacrifices some of the subtleties of Goldmann perimetry must substitute efficiency, reliability, simple operation, and high patient acceptability in order to supplement the Goldmann examination for clinical use."* (Bobrow, 1982)

In the course of more than 34,000 visual field exams conducted at the Department of Ophthalmology of the University of California at Davis, Keltner (1983) notes that automated perimetry became an accepted form of visual field testing for routine clinical purposes during the period from 1976-1982. In this academic setting, 27% of visual field tests were conducted manually and 73% with automated devices during the six-year period.

Perimetrists' satisfaction with their devices could be expected to influence diffusion, as could patients' responses to testing: Trope and Britton (1987) surveyed patients and technicians regarding perimeter preferences: patients preferred manual testing while technicians preferred automated (Humphrey).

1990s and beyond: further diffusion with evolving definition of clinical role for automated perimeters

Townsend (1991) describes the historical and technical development of perimeters as a logical linear evolution culminating in automated devices exemplified by the Humphrey Field Analyzer.

In 1995, Katz reported: *"Automated perimetry has become the standard for visual field testing over the past decade, replacing manual Goldmann perimetry."*

The major presence of automated perimeters in the more recent literature, along with the variable quality of the research as conducted and reported (discussed below) make designation of a standard less straightforward from the available literature than it would have been two decades ago. Further, the "gold standard" for diagnostic accuracy studies will vary according to the disease under investigation. Although optimal diagnostic and front-line practice standards are not always the same, one would hope them to be.

Clearly, information from automated and manual perimetry is not completely identical, nor are the diagnoses or sub-sets of patient populations in which each is most productively employed; both can be argued to have roles in clinical practice.

Finally, many of the studies comparing Goldmann to Humphrey or other automated perimetry were diagnosis-specific (Table 2, Appendix), and thus cannot directly be extrapolated to device use in a heterogeneous VA C&P exam population. Weaknesses of the diagnosis-specific studies from VA's perspective include small numbers of patients and investigation of relatively uncommon diseases.

<u>Results, Assessment question #1:</u>
B. Do manual and automated perimeters provide complementary information?

Within VHA, an advantage attributed to the Humphrey Field Analyzer is its usefulness in glaucoma diagnosis (Townsend, 2002). Glaucoma is a leading cause of irreversible blindness, worldwide, and thus figures prominently in the visual fields testing literature: the largest category of comparative studies reviewed for this report (Table 2, Appendix) is that focused on glaucoma.

Increased intra-ocular pressure, once part of the definition of glaucoma, is now recognized as the most important risk factor among several, rather than a necessary component of the disease. Definitive glaucoma diagnosis requires information beyond ocular hypertension and characteristic visual field defects (Danyluk, 1991; Sommer, 1996).

Hotchkiss (1985), reviewing the literature as background to a new study, reports that automated perimetry demonstrates 5-10% more field defects in early glaucoma than does manual Goldmann perimetry, and queries the extent to which these findings might represent false positives. Katz (1995) attempts to clarify the same issue. Hotchkiss and Katz are abstracted in the first section of Table 3 (Appendix).

Differences both in presentation of perimetry results and in their interpretation may contribute to these results. Wilensky (1989) proposes that automated perimetry is more precise than manual because the numeric values obtained for each test location with the former lend themselves to a wider variety of data analyses and comparisons. At the same time, automated perimetry offers scope for additional patient-based factors to (negatively) influence reliability. Wilensky concludes that Goldmann (manual) perimetry may be more demanding to perform, but automated may be more difficult to correctly interpret.

Hotchkiss (1985; Tables 3 and 3a, Appendix) is among the more rigorous of glaucoma diagnosis studies reviewed for this report. While these authors did use additional glaucoma criteria, the study still fell short of ideal methods: blinding to other test results was inconsistently applied, and follow-up with repeat automated perimetry to further clarify any false positive glaucoma field tests was not performed.

The only other study meeting methods quality criteria for this report (Katz, 1995; Tables 3 and 3a, Appendix) followed glaucoma suspects with repeat perimetry and observers blinded for at least some of the study data collection, but these authors did not report optic disk and nerve fiber layer (of the optic nerve head) data as contributing to glaucoma diagnosis.

With the exception of Hotchkiss (1985) and Katz (1995), studies comparing Goldmann to Humphrey or other automated perimeters for glaucoma failed to meet methods standards for diagnostic test studies. Shortcomings were a lack of independent corroboration of glaucoma diagnosis by clinical criteria or follow-up, and failure to blind test interpreters to other diagnostic information.

Although both the Hotchkiss and Katz studies are less than completely definitive, they are the most rigorous available for glaucoma and thus lend additional credibility to the overall impression that manual and automated perimetry provide complementary information. These two relatively rigorous studies both reach the same conclusion in support of complementary roles for manual and automated perimetry.

A caveat for the glaucoma studies as a group is the overall lack of standardization among automated perimeter testing strategies (Table 3a, Appendix). In this context, it is difficult to generalize results from one automated perimeter to others. However, automated perimeters do generally restrict testing to the central field for glaucoma patients, while Goldmann tests include the peripheral field.

Further, Hotchkiss (1985) offers enlightening insights into the differences between manual and automated perimetry: for practitioners accustomed to interpreting graphically linear Goldmann results, the graphically "profile", gray-scale or numeric results from automated perimetry require a quite different interpretative approach. Hotchkiss believes that relative difficulties are likely to be compounded when a patient is followed by different clinicians, or with different automated perimeters.

Although not all automated perimeters use identical programs, credibly rigorous research documents that automated perimetry will detect field changes due to glaucoma before these changes are evident on manual examination. Automated perimetry also requires longer sessions and greater concentration from patients in spite of its ease for technicians, while focused on a generally less voluminous area of the field in glaucoma suspects than manual perimetry.

Wilensky (editorial, 1989) concurs that automated perimetry detects glaucoma field loss sooner than manual perimetry. Wilensky also believes automated perimetry to be less valuable for eyes with very advanced field loss. In this case, there may be only a few test locations where responses to stimuli remain, limiting ability to detect change over time and making testing very discouraging for patients.

As background to new research, Wall (1991) notes that automated perimetry is time-consuming and monotonous for test subjects, who may fatigue, change head position, and then report visual field defects attributable to artifact. According to reports cited by Wall, approximately 45% of glaucoma patients and 30% of normal subjects do not meet reliability criteria for automated perimetry. Since survey data (Trope, 1987) confirms patients' preference for manual perimetry, these patient factors also argue that manual and automated perimetry fulfill complementary roles.

Opinion in the literature thus concurs with opinion within VHA (Townsend, 1991;2002) that manual and automated perimetry are complementary. Further, Townsend (2002) confirms that manual and automated perimeters typically measure different proportions of the entire volume of the normal visual field (figure 2, Appendix); the location within the field that is of primary interest in a particular clinical situation should guide selection of perimeter.

Model practices from academic settings may help to refine these perimeters' respective roles. Keltner (1983) reported clinical practice in the Department of Ophthalmology, University of California, Davis, at that time. All patients undergoing visual field examinations in there are first tested with automated suprathreshold static perimetry. When a defect is found, Goldmann kinetic perimetry may then be used to better define the defect, or to establish a baseline with another type of perimetry for future follow-up.

In Keltner's academic context, manual perimetry also can be used for teaching purposes. Finally, ready access to quality manual visual field examinations produced by highly trained technicians in an academic clinical department encourages this approach. Keltner further notes that a standard protocol, "luminance sequencing", developed for the Fieldmaster model automated perimeter, is used to interpret visual field abnormalities and monitor progression over time.

Bobrow (1982) reported similar experience in other academic departments where Goldmann perimetry is also available and used when judgments concerning progression of field loss are needed.

Bobrow reported that automated perimetry was practical in his clinical setting: it was able to be reliably performed by all department nurses, technicians, and secretaries, while only registered nurses there were adequately trained and able to perform Goldmann perimetry.

After presenting a number of individual cases in perimetry for neuro-ophthalmic disease, Keltner (1983) concludes that automated static perimetry can occasionally specify defects better than can careful kinetic manual perimetry for patients with optic nerve disease.

As reported above, a similar perception, supported by rigorous studies, holds for the ability of automated perimetry to detect glaucoma field changes earlier than manual perimetry (Hotchkiss, 1985; Katz, 1995). However, definitive glaucoma diagnosis requires both perimetry and optic disk examination, arguing for a need that corroborating diagnostic information rule out false positive glaucoma findings when only visual field data are used. Among the comparative glaucoma studies reviewed for this report, only Hotchkiss (1985) and Katz (1995) provided such information.

Evidence for this review question thus indicates that manual (Goldmann) perimetry remains a standard under statute and for its entrenchment in training and practice. In spite of its reliance on highly trained technicians, it is easier and less prone to artifact for patients, particularly the elderly or those otherwise susceptible to fatigue or to concentration loss. Goldmann may be relied on in academic settings for thorough exploration of the nature of field defects initially identified with automated perimeters. Automated perimetry has advantages in ease of operation, and diagnostic capabilities in sub-groups of patients. Automated perimetry is perceived as en route to replacing manual perimetry for routine practice. Finally, manual and automated perimeters typically measure different proportions of the entire volume of the normal visual field (Figure 2, Appendix); the location within the field that is of primary interest in any particular clinical situation should guide perimeter selection.

Results: Assessment question #2:
How do visual field defect rating indices available for either Goldmann or Humphrey perimeters assist VBA in evaluating disability and handicap?

VBA has developed a method for calculating and rating the average concentric constriction of visual fields in monocular field results from Goldmann perimetry. Reference values for this calculation are the extent of normal visual fields at eight principal meridians.

The VBA rating quantifies visual field defects relative to the normal field extent, but makes no explicit connection with functional vision in a way that would permit estimating the disability or handicap an individual might experience from his or her field defects (McBrine, 2002). Thus the rating in current use by VBA resembles that recommended by the AMA in 1958.

VATAP found only two studies (Johnson, 1983; Wood, 1992; first section of Appendix Table 4) that provided evidence to associate visual field defects with problems in performing specific activities; both studies address driving only. In the absence of further evidence, published opinion may be of some assistance: Wright (1999) advocates including both objective acuity or fields measurement plus individualized visual function data in visual disability and handicap assessment. According to Wright, visual function for individual and specific tasks must be assessed to determine degree of handicap.

Functional visual field indices are available for both Goldmann (Estermann, 1968;1982) and Humphrey (Colenbrander, 1992) perimeters. Mills (1986) reported that the AMA had adopted the Estermann index in 1984.

Direct patient questionnaires developed to measure and quantify visual disability and handicap (Keefe, 1999; Ross, 1999; Mangione, 1998; Hassell, 2000; Haymes, 2001) also are available and would facilitate demonstrations of correlation between visual field defects and difficulty with particular activities or with unsuitability for certain occupations. Of course, care to distinguish functional visual complaints or malingering is advisable (Keltner, 1985) when patients' subjective reports contribute to handicap assessments. Mills (1986) suggests that the Estermann functional binocular index contributes an objectivity lacking in patient reports to an overall assessment of disability.

The Estermann functional index has theoretical advantages over a scoring system that attempts to estimate disability or handicap from anatomic indices: it evaluates the total binocular field and thus simulates real vision more closely. Further, it is based on relative values of areas of the field for function rather than anatomy only.

Estermann index calculation involves a binocular grid, weighted to favor the more functionally important areas of the field. The grid can be superimposed over graphic results from any perimeter (Estermann, 1982). The index rating (functional score in percent) is calculated by counting grid units not obstructed by scotoma (blind areas) or other field defects.

As noted above, VATAP identified relatively few data correlating any visual field index with perceived or observed difficulty in vision-dependent tasks for either daily life or employment (Table 4, Appendix). The only functional sphere in which an intervention has been conducted to evaluate the relationship between visual field defects and performance is driving (Wood, 1992).

Visual disability and handicap rating are areas requiring substantially more, and more focused, research to fully support evidence-based decision making.

There is little consensus on an optimal measure for visual disability. However, there does appear to be some agreement that no single scale or measure is sufficient (Ross, 1984; Parrish, 1997), as detailed in Table 4 of the Appendix.

The British National Health Service (NHS) guidelines for physicians to certify patients as blind or partially sighted were provided in response to VATAP's electronic mail INAHTA query. Definitions from the NHS guidelines are detailed in Appendix Table 4, and include reference to functionally more important areas of the field.

Results, Assessment question #3: Does the literature support concerns regarding inter-rater reliability for the Goldmann perimeter?

"…Visual fields, being subjectively obtained, are notoriously difficult to assess and to reproduce, and this is made even more difficult by the lack of standardization in equipment and method." (Berry, 1966).

The perception that manual perimetry is an exacting task with variables related to the operator, and the corollary that automation increases standardization have been frequently reported (Keltner, 1983; Parrish, 1984; Enger, 1987; Johnson, 1987; Townsend, 1991; Stewart, 1992) since Berry published the statement quoted above. However, VATAP's literature searches identified only two studies quantifying variation on repeated kinetic perimetry (Parrish, 1984; Berry, 1966; both detailed in Table 5, Appendix). Parrish performed both static and kinetic testing on the same perimeter (Perimetron automated), making these results not directly relevant to VHA's review question. Neither Berry nor Parrish conducted studies primarily designed to assess Goldmann perimeter inter-rater reliability.

Finally, automated perimetry also is imperfect: reliability of Humphrey testing can be a problem, due both to patient (Wilensky, 1989) and to testing factors [Advanced Glaucoma Intervention Study (AGIS) Investigators, 1994]. The AGIS investigators found that for 16% of enrolled eyes in a randomized trial of therapy for medically refractory glaucoma, long-term fluctuations in Humphrey score were large enough to suggest change in glaucoma fields even though the time period was short enough to make change in disease status unlikely.

Bobrow (1982) reported the opinion that the results of Goldmann perimetry in the hands of a trained technician or ophthalmologist are uniform enough so that comparisons can be made among fields obtained by different examiners.

Again, VATAP identified only two analytic studies relevant to reliability of Goldmann perimetry (Table 5, Appendix); both compared kinetic to static testing on a single instrument, and thus neither provides a definitive answer to this issue from VHA's perspective.

Summary and Discussion

The literature reviewed for this report is devoted largely to describing the incremental technical development of automated perimeters. It seems reasonable to characterize this literature as representing the hypothesis-generating stage of technology development and evaluation, rather than the subsequent stage of clinical hypothesis-testing.

For the purposes of this report, perimetry research must be interpreted in the context of the highly individualized and subjective experience of disorder, impairment, disability, and handicap, and also in that of the subjectivity of human perception as measured by perimetry. These factors make the few available studies only a beginning to answering VHA's questions about the roles of different devices, particularly as the devices are used to define or rate disability and handicap for compensation.

VHA raised questions about perimetry at a time when the evolution of automated perimetry to replace manual appears to be in progress. How or at what point in time this process will be completed cannot now be defined precisely. In the interim, both types of perimetry have strengths and weaknesses that argue for retaining parallel availability to clinicians.

The literature covers a two decade period of transition from manual to automated perimeters for routine clinical use, and is notable more for its reasoned and usually cautious willingness to explore their respective roles than for its scientific rigor. Some of the perimetry issues that initiated this report, particularly that of evaluating and rating visual disability have been addressed in only one or two published studies.

Defining an optimal rating scale for visual disability thus remains problematic. VBA's existing anatomy-based index for rating visual field constriction is not supported by research documenting an association between anatomical visual field defects and disability or handicap.

Functional residual visual field indices for both major types of perimeter are available, as are instruments (questionnaires) designed to quantify visual handicap from the patient's perspective. Such data collection vehicles refine judgments resulting from the vision component of C&P exams. Some regulatory entities do incorporate specifics of visual fields data into licensing requirements for driving. However, VATAP did not identify data analyses able to define the connection between visual field defects and disability or handicap beyond those in that context.

The optimal method for assigning a handicap rating to visual field impairment remains controversial. As noted at the beginning of this report, the flexible links among impairment, disorder, disability, and handicap are amenable to influence by treatment and rehabilitation interventions as well as by an individual's adaptation and context. Attempts to measure, or assign numerical ratings to such idiosyncratic human phenomena are certainly desirable and perhaps necessary for purposes such as C&P exams, but an optimal scale remains to be defined.

In the highly individualized context of response to impairment, arguments can made both for and against incorporating patient self-reports or responses to standardized assessment instruments: it makes intuitive sense to ask the patient and to examine his or her performance of tasks requiring vision, while public agencies like VHA must avoid the appearance of subjectivity in ratings. Unfortunately, the available research offers little substantive assistance along these lines. Until stronger research is available, VHA policy makers may elect to follow the AMA's recommendation for a functional residual fields index, rather than the anatomical one currently used.

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Appendix

Figure 1. <u>Synonyms:</u> *Static versus kinetic perimetry* *(referring to behavior of stimulus lights in the two major visual field testing strategies)*

Note: Some instruments, including the Humphrey Field Analyzer, have both static and kinetic programs, confounding absolute distinctions between major classes of perimetry. This figure provides simplified generalizations for expediency.

Major class of perimetry	*Synonym(s)*	*Modifications*	*Devices*
Kinetic	Manual		• Goldmann perimeter • Tangent screen
Static	Automated	• Short wave length • Various programs, statistical packages, or algorithms (e.g., Humphrey 24-2, 30-2; Fastpac; Statpac 1and 2) • Frequency doubling • SITA standard • SITA fast • Blue-on-yellow • High pass resolution • Threshold strategy • Single intensity strategy	• Humphrey Field Analyzer (≥ 2 generations) • Octopus perimeter • Synemed Glaucoma • Dicon • Hippocampus • Peritest • Friedman Analyzer • Perimetron

Figure 2. Area of measurement for manual and automated perimeters (degrees from line of sight)

Direction of measurement	*Extent of normal visual field*	*Goldmann perimeter (kinetic) area of measurement*	*Automated perimeters (static) area of measurement*
Up	60	50	40
Down	75	70	55
Temporal	100	90	60
Nasal	60	60	50

Figure 3. Definitions: *World Health Organization International Classification of Impairments, Disabilities, and Handicaps*
(adapted from Colenbrander, 1996)

Visual disorder	Visual impairment	Visual disability	Visual handicap
The organ		The person	
Anatomical changes	Functional changes	Skills and abilities	Social & economic consequences

Table 1. Frequency of study types in search and end-reference retrievals by major assessment issue

Assessment question	Number of references
1. Are Goldmann and Humphrey tests comparable or complementary?	75 comparative studies: • 7 direct Goldman-Humphrey comparisons, diagnosis-specific • 68 other comparisons
2. Does published research support inter-rater reliability concerns for manual perimetry?	2
3. Visual fields and disability	4

Table 2. Comparative studies: frequencies within categories

Category	Number of studies in searches (% total comparisons)
Within-device technical refinement comparison	13: all within-Humphrey (18)
Diagnosis-specific (other than glaucoma)	14 (17)
Generalized comparison (other than Goldmann Vs. Humphrey)	10 (14)
Glaucoma	40 (51)
Total comparative studies involving Goldmann perimeter	**77**

Table 3. Details of studies comparing manual (Goldmann) to automated (Humphrey or other) perimetry; two static to kinetic comparisons on the same instrument included

Reference	Comparison	Clinical setting/methods	Results/comments
Glaucoma studies approximating methods standards			
Hotchkiss (1985)	Goldmann Vs. Peritest	Glaucoma: • field loss on Goldmann • suspected glaucoma • normal eyes	• 50% of suspected glaucoma eyes had abnormal Peritest but normal Goldmann • Early defects on Peritest likely to represent glaucoma damage rather than false positives • ***Optic disc and nerve fiber layer data for all subjects interpreted by blinded observers*** • *Blinded interpretation of visual fields not noted* • In suspected glaucoma eyes, manual perimetry did not detect many of the scotomas (mostly deep with steep margins) demonstrated by automated perimetry • 50% of eyes with abnormal Peritest fields also had other signs indicating glaucoma damage
Katz (1995)	Goldmann Vs. Humphrey	Ocular hypertension without field loss on detailed Goldmann	• 22% of subjects without field loss on Goldmann had abnormal fields on one Humphrey exam • 15% had abnormal fields on two consecutive Humphrey exams
Glaucoma studies with design flaws			
Batko (1983)	Goldmann Vs. Friedmann	Early glaucoma Vs. normal	• Friedmann at least as sensitive as Goldmann for early glaucoma field defects, rapid and requires less operator training
Enger (1987)	Previous Goldmann results Vs. Humphrey STATPAC (MD or PSD)	Nerve Fiber Layer Study in glaucoma	Humphrey: • Se = 97% • Sp = 90%
Schmied (1980)	Goldmann (average level of proficiency among 12 perimetrists) Vs. Dicon	• Chronic open angle (slit lamp showing disk cupping); or • Suspected glaucoma (>22mmHg on tonometry)	• Dicon detected more field loss, including eyes with no loss on Goldmann • Author concludes that results were more likely false negative Goldmann than false-positive Dicon since results remained the same on re-testing; although only a few patients re-tested at time of publication • Manual perimetry may have been inadequately performed, as defects were found only on thorough re-testing • Automated perimetry more sensitive to field loss than even most scrupulous manual exam • Either form of perimetry more sensitive in detecting abnormalities than optic disk biomicroscopy, but automated corresponded better to disk cupping and tonometry than did manual
Morin (1979)	Static Vs. kinetic (both Tübinger)	2000 patients (static and kinetic fields corresponding, reliable patient) referred for glaucoma evaluation over 10 years	• Listing of static versus kinetic findings, no systematic comparison or analysis • Inclusion criterion of corresponding fields eliminates possibility of enlightening comparison
Agarwal	Goldmann	POAG	In 3 monthly follow-up for 9 months, Humphrey detected more defects and documented

Reference	Comparison	Clinical setting/methods	Results/comments
(2000)	Vs. Humphrey		progression in > number of eyes.
Stewart (1992)	Static Vs. kinetic programs (both on Humphrey)	Glaucoma or ocular hypertension (nasal peripheral field)	• Optic disk and visual field changes included in glaucoma diagnosis • “Masked” interpretation reported, but not fully defined • Two nasal programs agreed in diagnosis for 72% of glaucoma or ocular hypertension eyes ($p< 0.025$) • In 20 of 187 glaucoma or ocular hypertensive eyes, defects were found in nasal peripheral field when central 30 degree field was normal :17 by kinetic, 11 by static ($p> 0.05$) • Static testing has no advantage over kinetic
Vinuesa (1990)	Goldmann Vs. Hippocampus	Suspected or confirmed simple chronic glaucoma	• Detection of absolute paracentral scotomas in 32% of eyes by Hippocampus; in 7.5% of eyes by Goldmann • Detection of relative scotomas in 0% of eyes by Hippocampus; in 10% of eyes by Goldmann • Glaucoma diagnosis in 65% of eyes by Hippocampus, by Goldmann in 12.5% • Same examiner performed all tests, but blinding to other diagnostic information not reported • Diagnostic criteria for glaucoma not reported
Miscellaneous comparisons			
Hart (1983)	Goldmann Vs. Dicon	Calibration in normal subjects	Differences small but statistically significant
Trope & Britton (1987)	Goldmann Vs. Humphrey (program 30-2)	Patients attending glaucoma service at Toronto General Hospital	Patient and technician satisfaction: • 60% of patients preferred Goldmann • Patients found fixation easier to maintain with Goldmann • Technicians strongly preferred automated (Humphrey) • Humphrey took 25% longer for both eyes Humphrey diagnostic accuracy with Goldmann as standard: • Sensitivity: 90.3% • Specificity: 91% • Not reported: diagnostic criteria for glaucoma, blinding of test interpreters • Random allocation of patients to order of perimeters, though all received both
Other diagnoses			
Beck (1985)	Goldmann Vs. Humphrey	Ocular hypertension, neurologic disorders, normals	• Humphrey found defects in 21% of ocular hypertension eyes without Goldmann defects • 9% of automated fields inadequate due to fixation losses • 2% of manual fields inadequate
Riemann (2000)	Goldmann Vs. Humphrey	Ptosis fields	• 75% of Goldmann, 29% of Humphrey tests demonstrated at least 15° of field loss ($p = .001$) • Both effectively document fields • Humphrey requires longer exam time and may be less sensitive indicator of loss • All studies performed by same technician (among authors)

Reference	Comparison	Clinical setting/methods	Results/comments
Wong (2000)	Tangent screen Vs. Goldmann Vs. Humphrey	Detection and localization of occipital lesions (homonymous hemianopia/ well-defined MRI infarcts)	• All three perimeters revealed homonymous field defects that respected vertical meridian, detected presence of post-chiasmal lesions in all 12 patients • Fields obtained with tangent screen and Goldmann agreed with each other and corresponded well with location on MRI • Humphrey showed incongruous homonymous defects, inaccurately localized in two patients • Goldmann and tangent screen showed macular sparing in 9 patients (agreement with MRI) • 30-2 program on Humphrey failed to detect macular sparing in 3/9 patients, 24-2 program detected no macular sparing • Humphrey over-estimated extent of field loss in 1 patient; in this patient, Goldmann and tangent both more accurately localized the lesion as shown on MRI • Summary: all three perimeters detected post-chiasmal lesions, but localization with Goldmann and tangent screen more closely approximated MRI
Safran (1993)	Goldmann Vs Octopus 2000R program for neuro-ophthalmology disorders	Retinitis pigmentosa	• Small N: 3 patients total, 2 received both tests • Article organized as 3 separate case reports, no aggregate data analysis • Program provided useful information: appropriate delineation of mid-peripheral field involvement, and of sparing of central and peripheral areas • Octopus superior to Goldmann in revealing partially functional areas
Wall (1991)	Goldmann Vs. Humphrey high pass resolution perimetry (program 24-2 and ring test)	Pseudotumor cerebri, normal controls	• Humphrey 24-2 Se = 83%; Sp = 78% • Ring test Se = 72%; Sp = 89% • Differences between Humphrey programs NS • Goldmann perimetrist blinded to Humphrey results; Goldmann results examined "in asked fashion"
Bobrow (1982)	Goldmann Vs. Fieldmaster Mode 200l	167 consecutive patients requiring perimetry at academic Department of ophthalmology over 5 months (diagnoses: neurologic, glaucoma, retinal, trauma, others), of whom 98 received both tests	• Nurse conducting second test (Goldmann) did not have first test (Fieldmaster) results • Correspondence between results for Fieldmaster and Goldmann 6 days apart on patients with stable glaucoma under good control • Fieldmaster delineated defects also present on Goldmann in 95% of patients receiving both tests • 11% of Fieldmaster tests found new defects on present on previous Goldmann but later confirmed • Failure to complete test rate < 2% for Fieldmaster • Patient acceptance increased with staff experience

Abbreviations:
MD, mean difference (Humphrey numerical index)
MRI, magnetic resonance imaging
NS, not significant
POAG. Primary open angle glaucoma
PSD, pattern standard deviation (Humphrey numerical index)
Se, sensitivity
Sp, specificity

Table 3a. Details of testing within glaucoma studies

Reference	Devices	Details of testing
Morin (1979)	Tubinger oculus automated: static and kinetic	Static: fixation out to 30°, every second degree along 45° and 135° meridians Kinetic: from non-seeing (30°) toward fixation
Katz (1995)	Humphrey	C-30-2 program
	Goldmann	≥4 isopters encircling 360° Two additional isopters limited to nasal field "Numerous" static presentations
Batko (1983)	Friedman Analyzer (presents stimuli of identical intensity at ≥ 2 locations simultaneously)	Central 25°; 0.4 log unit brighter than working threshold 33 stimulus positions
	Goldmann	**"Techniques standard at the institution":** Isopter near 10-15 position, another at 25-30, with static spot checks within these isopters; 2-3 isopters in "more peripheral visual field" "Experienced perimetrist plotted field as carefully as possible, knowing that subjects were suspected to have glaucoma accompanied by subtle defects"
Schmied (1980)	Octopus	One peripheral and 2 central isopters, all within central 30°; Static spot-testing to search for scotomas Double testing "approximately 70" locations, once within 30° isopter, once within entire field
	Goldmann	**1 peripheral and 2-3 central isopters within 30°** Static spot testing
Vinuesa (1990)	Hippocampus	"Screening program" of area centered at eccentricity of 30° on horizontal meridian and 24° on vertical meridian
	Goldmann	"Conventional perimetry with type I stimulus and corresponding isopters I-4, I-3, I-2, I-1"
Beck (1985)	Humphrey	Central 30-2 test with white $4mm^2$ target and near correction as appropriate
	Goldmann	Central isopter at 25° with static spot checking at 76 points within central 15° Peripheral isopter at 85° Additional isopters to define any defects found
Hotchkiss (1985)	Peritest	151 points within central 25° 1-a signal test of central field Standard peripheral group used for peripheral field
	Goldmann	Armaly –Drance technique: Two central isopters: • Threshold kinetically tested in15° meridional increments for 360°; additional meridians tested 5° and 10° above and below horizontal meridian nasally • second central isopter plotted between 5° and 10° from fixation Static spot checking within each isopter along 30° meridians Lowest stimulus that reached maximum nasal periphery used to plot peripheral isopter every 15° for 360° Spot checking within peripheral isopter

Table 4. Association of visual impairment measures with disability or handicap; definitions of low vision

Reference	Study purpose	Clinical setting	Results/comments
Studies providing evidence associating visual field defects with disability			
Johnson (1983)	To determine incidence of field loss in a large population, to examine the efficacy of the screening procedure, and to examine the relationship between peripheral visual field loss and driving performance	Automated visual field screening of 10,000 volunteers (20,000 eyes)	• Drivers with binocular field loss had accident and conviction rates twice those with normal visual fields • Drivers with monocular field loss had accident and conviction rates equivalent to subjects with normal fields
Wood (1992)	To investigate relation between visual field and driving performance	Young normal subjects with simulated binocular field defects	Constriction of binocular field to ≤ 40°significantly: • Increased time to complete course, ability to detect and identify road signs, avoid obstacles, and maneuver through limited spaces • Accuracy of road positioning also impaired • Speed estimation, stopping distance, or time taken for reversing and maneuvering tasks not impaired
Miscellaneous articles on visual disability or definitions of low vision			
Ross (1984)	To quantify visual defect	Chronic simple glaucoma (Oxford Eye Hospital, UK)	• Used piloted questionnaire about effect of vision on daily activities, but validity or reliability not reported • Results from a group of tests (near visual acuity, visual field, contrast sensitivity) are best predictors of difficulties in performing visually dependent daily activities
Mills (1986)	To compare automated Estermann and conventional manual scoring of visual disability	Severe glaucoma/ glaucoma practice	• Mean Estermann binocular score (residual visual field) = 57% (range,7% -99%) • Visual field disability instrument specific to this study, validity and reliability not reported: • Disability score = (100 - Estermann score): regression analysis identified 5 questions as best predictors of disability score
Parrish (1997)	To determine relations between visual field impairment (Esterman index), visual functioning, National Eye Institute VF-14), global QoL (SF-36)	Glaucoma	• Esterman scores moderately correlated with VF-14 (after correction for visual acuity), but correlation of acuity with fields inconsistent across patients in this study • SF-36 weakly correlated with Esterman
Murdoch (1997)	To measure effect of field constriction + acuity on estimates of blindness in Nigeria	6831 subjects ≥ 5 years who had screening exam for visual function including Friedman field analysis	WHO categories of blindness (measurements in better eye): • 4= acuity <3/60, visual field constricted to < 10° • 5 = acuity < 1/60, field constricted to < 5°
Dandona (1998)	To devise blindness criteria using extent of constriction of visual fields measured by automated static (Humphrey) perimetry	Reliable constricted visual fields obtained at Prasad Eye Institute, Hyderabad, India	Visual field blindness definition: A zone with at least 75% of test points ≤ 0 dB and no point ≥ 10 dB has absolute loss of sensitivity

Reference	Study purpose	Clinical setting	Results/comments
Mangione (1998)	To identify content area for vision-related quality of life instrument	Focus groups recruited from academic ophthalmology practices, non-profit eye care foundation	Instrument development Acuity but not field constriction reported for participants
Wright (1999)		Telephone survey for Royal Victorian (Australia) Institute for the Blind employment survey: working age adults with visual impairment	• Self-reported degree of vision impairment was inversely related to level of handicap • Experience, training, corrective devices, and vision substitution skills may explain apparently counter-intuitive result • Visual fields and acuity not directly tested, subjects self-reported impairment and underlying disease cause in telephone interview
Keeffe (1999)	Instrument development, validation, reliability testing		Visual field constriction not reported or included in analyses
Leat (1999)	To re-evaluate definitions of low vision, visual impairment, and disability	Critical review of existing definitions	• Contrast sensitivity should be included in evaluation of disability Proposed definitions: • Visual Impairment: best monocular or binocular visual acuity < 6/7.5, total horizontal field < 146° (Goldmann III-4e) or < 109 ° (Goldmann III-3e) and contrast sensitivity <1.5 (Pelli-Robson) • Visual disability: best monocular or binocular acuity <6/12 or contrast sensitivity <1.05.
Hassell (2000)	Further development of Impact of Vision Impairment profile into practical instrument for low vision rehabilitation		Instrument development for rehabilitation setting
Rubin (2001)	To examine relationship between psychophysical measures of visual impairment and self-reported difficulty with every day visual tasks in population sample > 65 years	community-dwelling residents of Salisbury, MD, between 65 and 84 years	• Multiple regression analyses adjusted for demographic factors, cognitive status, depression, number of co-morbid factors • Vision measures (acuity, contrast and glare sensitivity, stereo acuity, visual fields) are significant independent risk factors for self-reported visual disability in older population • Visual fields measured with 81 point single intensity screening strategy on Humphrey; square root of number of points missed used for analysis
Haymes (2001)	To develop a weighted version of Melbourne Low-Vision Index (MLVAI) for personal impact of disability in ADLs	Low-vision and normal control adults recruited from Australian clinics, foundations, support groups	MLVAI score significantly correlated with all vision measures: • Near-word acuity had highest correlation, followed by Melbourne edge-test contrast sensitivity • Visual field (anatomical total visual field score, specific to this study) had weakest correlation
VanNewkirk (2001)	To document cause-specific prevalence of eye diseases causing bilateral visual impairment	Population-based prevalence study: adults in Victoria, Australia	**Definitions** (acuity + visual field): Visual impairment: less-than-driving vision (<6/12 ≥ 6/18 and/or homonymous hemianopia), subcategories: • Moderate, <6/18≥6/60 and/or< 20°≥ 10° radius field • Severe, <6/60≥3/60 and/or<10° ≥ 5° radius field • Profound, <3/60≥3/60 and/or<5° radius field • Australian legal blindness definition includes both severe and profound categories above

Reference	Study purpose	Clinical setting	Results/comments
NHS (2002)	Guidelines for physician assignment of patients to full blind and partial sight categories	"Record of examination to certify a person as blind or partially sighted" (Form BD8)	National Assistance Act says that a person can be certified as **blind** if he or she cannot do any work for which eyesight is essential (3 groups): • < 3/60 Snellen; 1/18 Snellen is not certifiable as blind unless visual field is also "considerably restricted" • 3/60 ≤ 6/60 Snellen and also "very contracted field of vision" • ≥6/60 and also "very contracted field of vision especially if contraction is in the lower part of the field" **Partial sight:** "substantially and permanently handicapped by defective vision caused by congenital defect or illness or injury": • 3/60 ≥ 6/60 Snellen with full field • ≤6/24 Snellen with moderate contraction of field • 6/18 Snellen or better with gross field defect (e.g., hemianopia)or marked field contraction (e.g., retinitis pigmentosa or glaucoma)

Abbreviations:
dB, decibels
ADL, activity of daily living
NHS, National Health Service, UK
SF-36, Medical Outcomes Study 36 item short form
VF-14, National Eye Institute 14 item visual function score
QoL, health-related quality of Life

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Table 5. Kinetic perimetry inter-rater reliability

Reference	Study purpose	Clinical setting	Results/comments
Goldmann perimeter			
Berry (1966)	To compare static and kinetic field plotting and measuring (both on Goldmann perimeter) by 2 well-trained observers	normal subjects and glaucoma patients, repeat tests on same day separated by rest periods	*Normal subjects:* • kinetic testing: visual field area differences not significant at $p = 0.05$ • static testing: differences between observers for perimetry not significant, but difference in visual field area was significant at $p = 0.01$ *Glaucoma subjects*: • kinetic testing: difference in area not significant at $p = 0.05$ • static testing: differences in area significant at $p = 0.05$ *Conclusion:* • 2 well-trained observers performing static and kinetic perimetry on the same normal eyes show only NS differences; differences in area measured, though small, are significant • glaucoma fields vary more between observers, but differences still generally NS • patient variations are much greater than and overshadow small differences between technicians
Kinetic testing, other perimeters			
Parrish (1966)	To quantify reproducibility of static and kinetic (both Perimetron) visual fields results	Normal volunteers	• SD of kinetic isopter position is 2.6-5.5 degrees, with the greatest variation in the temporal field • > 10% of points show inward deviation of $\geq 5°$ compared with their neighboring points • re-testing of deviant points is required to distinguish an artifact caused by variable responsiveness from true localized defects

Abbreviations: NS, not statistically significant
SF-36, Short form, 36 item (global health related quality of life scale)