



Purpose

The ophthalmologic study which this communication proposes to report is part of a long term project conducted by the Atomic Bomb Casualty Commission (ABCC) to investigate the medical and biological effects of the atomic bombing in Japan.

The request for an ophthalmic survey was apparently initiated by the Committee on Ophthalmology of the National Research Council with the implied intent of determining what, if any, delayed injury to the eyes had resulted from the atomic bombing. The undertaking was prompted in considerable measure by the recent discovery of cataracts in cyclotron workers who had been chronically exposed to forms of radiant energy (neutrons and gamma rays) similar to those which were given off by the atomic bomb.

The assumed task of the study group was three fold: (1) to determine qualitatively, by history and examination, whether or not ocular lesions, other than traumatic, resulted from the atomic bombing; (2) what the approximate frequency of these lesions was in a sample group of the surviving population who had been near the hypocenter at the time of the explosion; and (3) to note any incidental findings that might be considered of significance or interest in a routine examination of the eyes of a Japanese population.

Personnel, organization, and procedure

The Ophthalmologic Survey Team consisted of Drs. David G. Cogan, S. Forrest Martin, and Samuel J. Kimura. The clinical facilities and most of the personnel were provided by the ABCC<sup>1</sup>. Selection of patients for the survey was made from the census files<sup>2</sup> of the ABCC and transportation of the patients to and from the Clinic was also made possible by the ABCC. The personnel of the Clinic, under the supervision of Pearl T. Kimura, R.N., consisted of two Japanese nurses, one bi-lingual secretary, one interpreter, and six part-time interns from the Red Cross Hospital<sup>3</sup> of Hiroshima. The equipment consisted in the main of two slit lamp biomicroscopes, one refracting unit, four ophthalmoscopes, one photographic apparatus for taking external pictures of the eye, and a miscellany of lesser items.

The Clinic quarters consisted of approximately 300 square feet in what had been a portion of the auditorium of Gaisen-kan ("Victory Building"), the temporary quarters of the ABCC, at the port of embarkation of Hiroshima. The Clinic was subdivided into two examining rooms, three interview cubicles, and one central waiting room.

The patients of the survey group were brought to the Clinic in lots of ten and of the non-survey group (to be subsequently defined) at irregular intervals. The patients were ushered into the Clinic by the secretary, referred first to a nurse for visual acuity determination, then to an intern for history taking, and finally to an ophthalmologist for examination. The history taking consisted of directed questioning regarding the systemic effects of radiation (e.g., vomiting, diarrhea, bloody stools, petechiae, and epilation) and an ophthalmic questionnaire (See Supplement A). The ophthalmological examination consisted of routine external, slit-lamp, and fundus study with other procedures where indicated.

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- 1 Under the direction of Lt. Col. Carl F. Tessmer
  - 2 Under the supervision of Mr. Richard Brewer
  - 3 By arrangement with Dr. H. Ikui

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The patients were divided into the following classifications.

Group I Survey Cases. (a) The 1000 patients making up this group were drawn at random from a list in the census files of persons within 2,000 meters of the hypocenter and in the "open" at the time of the atomic bomb explosion. The age distribution of this group and the distribution as a function of distance from the hypocenter are presented in the accompanying graphs (See Addendum). (b) A supplementary survey was made of all available persons listed in the ABCC census files as being within 1000 meters of the hypocenter. This amounted to 231 persons. The age and distribution as a function of distance from the hypocenter are presented in the accompanying graphs (See addendum).

Group II Non Survey Cases. The patients making up this group were contacted by means other than the random sampling of the survey group. Some were contacted through local ophthalmologists, some through referrals from other ABCC clinics, some others through newspaper publicity, and some were called in. From this group were separated those who were thought to have ophthalmologic lesions attributable to the atomic bomb.

#### Background and previous pertinent literature

The atomic bombs were dropped over Hiroshima on August 6, 1945 and over Nagasaki on August 9, 1945. On August 28, 1945 a plan was submitted by Colonel Ashley W. Oughterson, MC, for the study of atomic bomb casualties. The organization was directed by Brigadier General Guy B. Denit. A mission from the Manhattan Project was assigned to the determination of the residual radioactivity in the bombed cities. Considerable assistance was obtained from the Japanese Government groups who had made the preliminary observations, and at the suggestion of the Supreme Commander there was appointed a "Joint Commission for the Investigation of the Effects of the Atomic Bomb in Japan". The report of this commission, summarized in part in the article of Liebow, Warren, and DeCoursey<sup>4</sup>, provides the most comprehensive survey of the terrain, the physical characteristics of the land, and the medical and biological effects on the population, including many illustrations and eye-witness accounts.

A resumé of the Joint Commission's report is beyond the scope of this survey, but it is noteworthy that the casualties were divided into mechanical injuries, thermal injuries and injuries from ionizing radiations. Mechanical injuries were those resulting from falling timbers and flying debris; injuries with glass particles from shattered window panes were especially frequent. Such injuries were sustained at distances of at least 4,000 meters from the hypocenter and were due to the blast of the bomb. Thermal injuries were due either to radiant heat, in which case the heat was intense but lasted for only a fraction of a second, or due to flame burns. The effects of radiant heat were evident in the form of burns up to 4,000 meters from the hypocenter, but rarely did they result in second degree burns at a distance greater than 3,000 meters. Being of short duration they produced characteristically a "profile" type of burns with protection of structures not in a rectilinear projection from the bomb. They also produced relatively more superficial charring and less deep penetration in comparison with flame burns. They

<sup>4</sup> Liebow, Warren, DeCoursey: to be published

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further produced curious configurations according to the clothing which was being worn at the time; thus burns often showed patterns where the overlying clothing had been of varying thickness, and clothing that had had a light and dark design often showed burns selectively under the dark portions, reproducing a design on the skin with remarkable fidelity. The flame burns resulted either from the spontaneous ignition of the clothing by the radiant heat or from the general conflagration that followed the bombing. Most of the early deaths, that is, those occurring within the first ten days, were due to mechanical or thermal injuries.

The injuries from ionizing radiations were theoretically attributable to any or all of the following forms of energy: visible rays, ultraviolet rays, gamma rays and neutrons, and the only significant source was direct radiation from the bomb at the time of the explosion. It is thought that there was insufficient induced radiation on the ground or deposition of fission products to have had a harmful effect. It is not clear what effect the visible and ultraviolet radiations had on the body as a whole but reference will be made to possible ocular effects subsequently. Most of the radiation effects were due to neutrons and gamma rays, and what the varying effect was of each is probably of academic interest only. Although the proportion of neutron to gamma rays is known to decrease as a function of distance from the bomb, information on the absolute amounts of energy of each is not publicly available.

It is commonly stated that the electromagnetic radiations resulting from the bomb had the same general distribution as that of the sun.

The peak effects of the radiation became evident at ten days to two weeks after the bombing and were manifest by epilation, purpura and drop in white blood count. A host of other symptoms were also frequent (diarrhea, anorexia, fever, etc.) probably attributable to radiation but hard to separate from the results of the unsanitary conditions following the bombing.

The effect of shielding was, of course, of prime importance in determining the type of lesion and no doubt was responsible in large measure for the diversity of lesions which were produced. Those who were in the open at the time of the explosion were exposed to radiant heat and ionizing radiation; those who were protected by wooden buildings were not exposed to radiant heat but were exposed to ionizing radiations; while those who were in concrete buildings were effectively protected from both.

The ocular effects of the atomic bombings have already been the subject of numerous publications<sup>5</sup>. The first report was apparently that to the Section of Preventive Medicine of the West Kyushu Military District by Matsuoka<sup>6</sup>, ophthalmologist of the Japanese Army rescue squad sent to Hiroshima on August 9, 1945. Of 492 patients within two kilometers of the hypocenter, 453 had conjunctivitis, 3 had burns of the eyelashes, and one had infiltration of the cornea. No lesion of the eye was found attributable to the direct effect of the blast. Case reports of atomic bomb effects on the eye followed by Hata<sup>7</sup> on perforation of the eye with glass

5 For the sources of reference in the Japanese literature, we are indebted to Dr. Ikui

6 Matsuoka, H.: Unpublished

7 Hata, E.: Injuries to eyes by atomic bomb; Nippon Rinsho Vol 3, #11-12, 1945.

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and separation of the retina by contusion; by Shoji<sup>8</sup> on cataracts occurring within a few weeks after the explosion and presumably due to the direct effect of the blast; by Ikui<sup>9a,9b</sup> on ectropion of the lid from burns of the face and on concussion cataract; and by Oyama and Sasaki<sup>10</sup> on burn of the cornea and retina. A brief report on the acute effects of the Hiroshima eye casualties was also given by Yoshimoto<sup>11</sup> and Shoji<sup>8</sup>.

The first ocular study of any considerable series was made by Tamura, Ikui, Nakano, Hiwatashi and Oshio<sup>12</sup>, on patients from the Nagasaki area who were within two kilometers of the hypocenter at the time of the explosion. The acute effects noted were: 1) thermal burns of the eyelids which were remarkable in leaving a minimum of scarring; 2) keratoconjunctivitis lasting only a few days and presumed to be due to ultraviolet radiation; 3) iridodialysis, luxation of the lens, hemorrhages in the retina and vitreous, and separation of the retina, all resulting from the direct effect of the blast; and 4) injuries by foreign bodies of which splinters predominated. Effects coming on 10-14 days after the bombing were noted in patients with radiation sickness and consisted of hemorrhages in the lids, conjunctiva, and retina and occasionally infiltration and necrosis of the cornea. The retinopathy, consisting of exudates as well as hemorrhages, was especially noteworthy as it was found in 22 of 115 patients on whom ophthalmoscopic examination was done.

These same authors made a patho-histologic study<sup>13</sup> of 43 eyeballs removed from 29 persons who had died 20 to 40 days after the atomic bombing of Nagasaki. Most died of bacteremia complicating radiation sickness. Colonies of bacteria were frequently found in the retinal vessels and occasionally free in the retina. The retinal hemorrhages were not remarkable and it was noteworthy that there was no evidence of disease in the retinal vessels. The white spots which had been seen clinically had their histologic counterpart in cytoid bodies (associated with hemorrhages), collections of white blood cells, colonies of bacteria and albuminous material. Separation of the retina of slight degree was occasionally found, mainly in the posterior segment but also adjacent to the ora serrata. The choroid was frequently infiltrated with monocytes, plasma cells, and lymphocytes and contained bacterial colonies in the vessels and free in the tissue. The colonies were sometimes associated with cellular reaction and sometimes without cellular reaction. Necrosis of the cornea and adjacent conjunctiva was present in one case. Vacuoles in the equatorial region of the lens were found in six cases, and the nuclei of the equatorial cells which lay beneath the capsule were degenerated in two cases with evidence of swelling and disintegration of a thin layer beneath the anterior and posterior capsules.

- 8 Shoji, Y.: Injuries of eyes by air attacks. *Ganka Rinsho Iho*, Vol 40, #1, p 1, 1946
- 9a Ikui, H.: A case of ectropion of lid after burns of the face by atomic bomb. *Ganka Rinsho Iho*, Vol 40, #2, p 21, 1946
- 9b Ikui, H.: A case of contusion cataract by blast of atomic bomb. *Ibid.*
- 10 Oyama, A. and Sasaki, T.: A case of burn of the cornea and retina by atomic bomb. *Ganka Rinsho Iho*, Vol 40, p 177, 1946
- 11 Yoshimoto, R.: Ocular injuries from air attacks; abstract in *Ganka Rinsho Iho*, Vol 41, p 15, 1947
- 12 Tamura, S., Ikui, H., Nakano, K., Hiwatashi, R., and Oshio, S.: Ocular lesions from the atomic bomb. *Ganka Rinsho Iho*, Vol 40, #5, p 90, #6, p 99, 1946.
- 13 Tamura, S., Ikui, H., Nakano, K., Hiwatashi, R., and Oshio, S.: unpublished.

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While the foregoing study has not been published, six of the specimens from this study were subsequently reported by Schlaegel<sup>14</sup> with the additional observation that there was slight thickening of the posterior capsules. An analogous patho-histologic study was made by Liura<sup>15</sup> but this report was not available to us. A further patho-histologic study has been made by Helenor Wilder<sup>16</sup> but not released as yet for publication.

The only instance of burn of the retina to have been reported is that of Oyama and Sasaki<sup>17</sup>. Their patient was searching the sky at the time of the flash, looking for the airplane. She had no immediate visual symptoms but 30 minutes later developed severe pain in the eyes, photophobia, and swelling of lids. She was hospitalized for one month but was not seen by an ophthalmologist at that time. The acute symptoms had subsided at the end of the month, and on examination she was found to have symmetrical opacification of the lower half of both corneas and a central scotoma of both eyes, most dense in a ring shape corresponding to the six to eight degree isopters. The fundi at first showed a grayish white zone, one third the size of the disc, on the temporal side of each macula and obliteration of the normal paramacular ring reflex. The fundi subsequently cleared up but the scotomata were permanent.

Benkwith<sup>18</sup> described in detail an instance of retinal hemorrhage with radiation disease, and Hirose<sup>19</sup> found retinal hemorrhages in 62 of 164 patients with presumed radiation sickness. Tanaka reported a staphyloma of the cornea resulting from an ocular injury caused by the atomic bomb and suggested that its pathogenesis was similar to the keloid formation elsewhere in the patient's body. The retinopathy associated with radiation sickness has been described also by Flick<sup>21</sup> with the additional observation that the changes were reversible.

Up to the time of the present writing no delayed cataracts have been reported in the literature, but one of the patients described in the present manuscript is being currently reported at the Kyushu Ophthalmological Society meeting (September 23, 1949) by Hirose<sup>22</sup>, and two additional cases of radiation cataract in the present report have been recognized by and called to our attention by Ikui.

Am. Jour. Oph.

- 14 Schlaegel, T.F.: Ocular histopathology of some Nagasaki Atomic Bomb Casualties. Am. Jour. Oph. 30, 127-135, 1947
- 15 Liura, H.: Patho-histologic examination of eyes of atomic bomb disease; Act. Soc. Oph. Jap. Vol 51, #5-6, 1946
- 16 Wilder, H.: Appendix to Pathology Section, Joint Commission Report-unpublished
- 17 Oyama, A., and Sasaki, T.: l.c.
- 18 Benkwith, K.B.: Retinal hemorrhages as seen in atomic bomb casualty. Am. Jour. Oph. 29, 799, 1946
- 19 Hirose, K.: Changes in ocular fundus with atomic bomb disease. Abstract in Ganka Rinsho Iho, #42, p 26, 1948
- 20 Tanaka, Y.: Staphyloma corneae, especially keloid-like thickening of the cornea by the atom bomb. Niigata Igakkai Zasshi Vol 61, #6, 1947
- 21 Flick, J.J.: Ocular lesions following the atomic bombing of Hiroshima and Nagasaki, Am. Jour. Oph. #31, 137, 1948
- 22 Hirose, K.: A case of cataract probably caused by the atomic bomb. Abstract to be published in Ganka Rinsho Iho Vol 44 (1950)

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Results

Group I (a) Survey of 1000 patients within 2000 meters of hypocenter.

A. Subjective visual phenomena

Practically everyone was aware of a bright flash of light, likened by many to a magnesium photoflash, followed, according to most observers, by a period of darkness lasting several minutes. The darkness was described variously as "black cloud", "smoky vision", or "yellow light". A few did not recall seeing the flash but were aware of the subsequent darkness. Despite the darkness, most believed their vision was normal at the time and none gave a description of seeing visual patterns such as might be expected with after-images. It seems likely, therefore, that the darkness described after the explosion was due to atmospheric conditions rather than to a disturbance in the visual apparatus.

Many patients stated that they were blind for some time after the explosion, but in most instances, this was due to swelling of the lids from burns with consequent closure of the eyes or due to keratitis and not to any neuroretinal lesion. However, one patient became temporarily blind in association with headache, followed by loss of consciousness ten days after the atomic bomb. The findings in this patient are now entirely normal. Another patient who developed gradual loss of vision, beginning one month after the atomic bomb and progressing to the present, showed advanced optic atrophy. The lesion is presumed to be intracranial and not related to the atomic bomb. One other patient developed difficulty in vision three days after the atomic bomb in association with amnesia and confusion. Three patients in whom the present examination of the eyes revealed no abnormality gave a history of partial loss of vision in both eyes occurring about one month after the atomic bomb and lasting two to four weeks. There was no marked radiation sickness in any of these three and in only one was there severe epilation and burns.

No patients in the survey group developed permanent central scotomata although several were allegedly looking in the direction of the bomb at the time of the explosion.

B. Keratoconjunctivitis

The number of patients who gave a history of bilateral keratoconjunctivitis within a few days or a few weeks after the atomic bomb, and not obviously due to trauma or burns, was 56. Of these, 42 gave a history of keratitis (e.g. photophobia, foreign body sensation, lacrimation, or redness) coming on within the first day and lasting for several hours or several days. The distances of these patients from the hypocenter was 1200 to 2000 meters. In none were there permanent sequelae. Discounting a few who believed they had symptoms for as long as a month, the cause of this early and temporary keratitis was presumably the ultraviolet radiation, for a similar history of keratitis is known to result from exposure to

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other sources of ultraviolet radiation. This is in keeping with the observation of some of the Japanese ophthalmologists who treated such persons within the first few days after the bombing. Many more presumably had keratoconjunctivitis due to ultraviolet radiation in whom the ocular symptoms were masked by the thermal injuries.

A history of delayed keratitis was obtained in fourteen, symptoms coming on within the first week in eight patients, within the first month in four, and after several months in two. The symptoms lasted from several days to several months. The distances of the three patients from the hypocenter were between 1100 and 2000 meters. In none were there permanent sequelae. How much these cases represent a delayed keratitis due to radiation and how much to other causes cannot be stated with any conviction.

While 56 patients thus gave a history of some sort of keratitis following the atomic bomb as far out as the periphery of the zone studied, it is surprising that there were not sufficiently severe exposures to produce permanent corneal opacities in view of the severe burns of the face that so many received. Thus, approximately one quarter of those in the series gave a history of burn of the face with loss of skin and often burn of eyebrows and eyelashes and yet had normal corneas at the present examination. None had permanent corneal opacities attributable to ultraviolet or infrared radiation. The reason for this sparing of the eyes is not apparent. The blink reflex would certainly not have been rapid enough. One factor may have been the naturally narrow palpebral fissure in the Japanese with the protective overhanging of the upper lid. It is also conceivable that some measure of protection against the long infrared rays may have been afforded to the eye, in comparison with the skin, by the fluid film that covers the eye.

It is also noteworthy that no case was found showing evidence of xerosis of the cornea or conjunctiva such as is occasionally found following severe X-ray or gamma ray exposure.

#### C. Lens changes

Abnormalities of the lenses were noted in 81 persons, in none of whom were the findings considered to be due to radiation. In four additional persons there were abnormalities of the posterior capsule or adjacent cortex which, while thought not to be due to radiation, were considered to show morphologic changes that suggested the radiation type. In none of the persons in the 2000 meter survey series was an unquestionable case of radiation cataract found.

Of the 81 persons with lenticular abnormalities, 38 had senile cataracts of the predominately cortical type, and 12 of the predominately nuclear type; 18 had isolated opacities in the embryonic nucleus or outlining the Y sutures; 8 had coronary cataracts; 5 had one or more bluish, lace-like opacities situated on, or in the

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embryonic nucleus; 3 had lamellar cataracts; one had a unilateral posterior polar cataract in association with high myopia; one had a unilateral collar button cataract in association with an old lesion of the cornea; one had congenital cataracts with microphthalmia; and one had a congenital white membrane on the anterior capsule.

The following is a description of the findings in the four patients who were considered to have morphologic changes somewhat suggestive of the radiation type. The first patient<sup>23</sup> was a 17 year old boy who had been 1550 meters from the hypocenter at the time of the explosion. He had had some vomiting and diarrhea for two weeks after the explosion and lost almost all of his scalp hair after a latent period of one month. The vision was O.D. 20/20-2; O.S. 20/30+2. His right lens showed a solitary subcapsular vacuole in the anterior cortex with a normal posterior cortex and capsule. The capsule of the left eye showed two tiny vacuoles in the posterior subcapsular (or capsular) region associated with tiny opacities and increased reflectivity. While abnormal, the changes were thought too slight to be diagnostic of radiation cataract.

The second patient<sup>24</sup> was a 17 year old boy who had been 1720 meters from the hypocenter at the time of the explosion. He had had burns of his face but no symptoms of radiation sickness and no epilation. His vision was O.U. 20/15. The right lens was entirely normal but the left lens showed a granular opacity over a 3 mm zone in the axial region of the posterior capsule. It was translucent but contained some scintillating high lights and a few polychromatic crystals. There were no vacuoles. The abnormality was considered an anatomic variant.

The third patient<sup>25</sup> was a 30 year old man who had had no radiation sickness and no epilation but in whom there was a faint arcuate opacity of the posterior capsule of one eye over a 3 mm zone eccentric to the axis and extending over a 2 to 3 mm area. This was also considered an anatomic variant.

The fourth patient<sup>26</sup> was a 31 year old woman who had been 950 meters from the hypocenter at the time of the explosion and subsequently developed severe gastrointestinal disturbances and epilation. The right lens showed several subcapsular vacuoles in the anterior and posterior cortex of the right eye and several small punctate dots in the posterior subcapsular region of the left eye. While the presence of these vacuoles and opacities are not accounted for, the absence of any opacification of the posterior capsules makes it seem unlikely that they were due to radiation.

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23	M.F. No. 255088
24	L.F. No. 258504
25	M.F. No. 263278
26	L.F. No. 221516

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The characteristic changes that make up radiation cataracts will be discussed subsequently. The fact that none occurred in this series suggests that the frequency at present is less than one in a thousand. It is entirely possible however, that some of this same group will develop cataracts in the future, as it is well known that the latent period for radiation cataracts may be a decade or longer.

The absence of exfoliation of the lens capsule may also be noteworthy in view of the large amount of infrared radiations to which the eyes of some of the patients must have been exposed.

#### D. Neuroretinal lesions

No lesions were found in the fundus which were thought to have been directly related to the atomic bomb. Two persons, of 75 years and 60 years respectively, had degeneration of their central retina but neither person had been looking at the sky at the time of the explosion and only one of them had symptoms of radiation sickness and epilation. They were thought to have senile macular degeneration. A third patient with normal visual acuity had some mottling of the central portions of the fundus. One patient gave a history of intermittent amblyopia beginning before the atomic bomb explosion, but the objective findings were normal.

One patient had a unilateral hole of the macula in association with high myopia, and three patients had evidence of an old chorioretinitis. Only eight patients had hypertensive and arteriosclerotic changes in the retinal vessels and in all of these the changes were mild; none had a vascular retinopathy. Two had a bilateral optic atrophy due in one case to methyl alcohol poisoning<sup>27</sup> and of undetermined cause in the other but presumably associated with an intracranial lesion. One patient had a unilateral optic atrophy and aberrant regeneration of the third nerve following a perforating injury of the cheek. One patient had a vertical and horizontal nystagmus following cerebral concussion. These last two cases were the only ones attributable to the atomic bomb.

#### E. Miscellaneous ocular findings

While of doubtful significance in reference to the atomic bomb, the following abnormalities were noted in the survey patients and are included here merely for the sake of completeness.

Trichiasis unassociated with entropion: 14 cases.

Thirteen of these patients were children and the trichiasis was associated with considerable epiblepharon in all

<sup>27</sup> This patient stated that when the atomic bomb struck Hiroshima he felt the end of the world was at hand and consequently decided to make his exodus in as pleasant a frame of mind as possible. Hence he took a large amount of alcohol.

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cases. The lashes of the inner aspects of the lower lids were usually the ones responsible and therefore caused contact with the cornea when the eye was adducted. Only in two of the patients was there also trichiasis of the lashes of upper lids. In three patients there was considerable keratitis epithelialis and some pannus formation in the lower inner angle of the cornea but it was noteworthy that the trichiasis had caused surprisingly little subjective disturbance.

Ptosis (unilateral) 1 case

Dacryocystitis 2 cases

Trachoma (quiescent and active) 13 cases. As the palpebral conjunctiva was not examined in all patients it is probable that many more had trachoma than here indicated.

Pterygium 12 cases

Inflamed pinguesculum 3 cases

Keratitis (inactive); type unspecified, 16 cases

- Herpetic, 1 case
- Phlyctenular, 1 case
- Traumatic, 3 cases
- Interstitial, 4 cases
- Epithelialis, 2 cases
- Ophthalmia Neonatorum, 1 case

Miscellaneous corneal abnormalities

One case each of white ring of cornea, senile marginal thinning, microcornea, and crocodile shagreen to posterior surface of cornea.

Argyll Robertson pupils 1 case

Albinism 1 case

Persistent hyaloid remnant 1 case

Asteroid hyalitis 2 cases

Phthisis bulbi 1 case

Myopia No record of the presence or absence of myopia was kept for the entire survey group but in a sample of 155 cases unilateral myopia was found once, bilateral myopia of 1.00 to 3.00 diopters was found in 7 (4.5%) and of 3-14 diopters in 4 (2.5%). Thus the incidence of myopia greater than one diopter was found for this small group to be of the order of 7%.

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F. Non-ocular findings

Observation was made on patients of the survey series as to burns of the face, epilation, and radiation sickness. Some burn of the face occurred in 394 patients, with loss of the skin of face in 256. Burns of the lids occurred in considerable, although undetermined, number of these patients. Yet the residual scarring of the lids and of the face was surprisingly slight. Ectropion of the lids was found in four cases only. Practically all of the burns were of the flash type and presumably had had considerable charring without deep penetration.

Epilation, for our purposes, means loss of head hair, eyebrows or eyelashes and may have been an immediate occurrence resulting from heat or a delayed occurrence (usually 10 to 18 days) resulting from the ionizing radiations. It may, of course, be both immediate and delayed owing to the conjoint effect of thermal and ionizing radiations but in this case, the delayed effect would be obscured by the immediate burns. Immediate burns of the head with loss of scalp hair, eyebrows, or eyelashes were noted in approximately 200 cases. In many, only the eyebrows and eyelashes were burned. Delayed epilation of the scalp hair was recorded as partial in 160 cases and practically complete in 65 cases (see graphs in Addendum). Delayed epilation of the eyebrows occurred in 22 cases and of the cilia in 16 cases. The duration of the epilation in the cases in which it was complete varied between several weeks to six months. No correlation was found between the duration of the epilation and the distance of the patient from the hypocenter.

While the entity of radiation sickness is well defined, it is not easy to separate some of its manifestations from infections not necessarily associated with radiation. Thus anorexia, malaise, nausea, vomiting, diarrhea, fever, and even petechiae which, along with reduction in the white blood cell count, make up the entity of radiation sickness may result from such unsanitary conditions as prevailed following the atomic bombing and are not necessarily due to the radiation. Without, therefore, knowledge of the white blood cell count during the critical few weeks following the bombing, it seems futile to attempt any evaluation at this late date of the presence or severity of the radiation sickness. Suffice it to say that approximately one-half of the surveyed persons gave a history of fever and gastrointestinal disturbances and approximately one-tenth gave a history of petechiae at some time during the first few weeks following the bombing.

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Group I (b) Survey of 231 patients within 1000 meters of the hypocenter, comprising the total available number of persons listed at present in the AECU census files as having been in this area at the time of the explosion.

A. Subjective visual phenomena

Of the patients in whom the objective findings were normal, 25 stated that they had impaired vision at, or within a few weeks following, the time of the explosion, but in only two cases was this thought to be significant in respect to the atomic bomb. The complaints of the others were thought to be due to presbyopia, myopia, senile cataracts, or senile macular degeneration, having no causal connection with the atomic bomb. Of the two patients who were thought to have had visual complaints attributable to the atomic bomb, one had had poor vision with "black clouds" before the eyes, and one complained of "red vision". In both instances, the visual difficulty had come on approximately three weeks after the bombing in association with radiation sickness (fever, pharyngitis, and petechiae) and both are presumed to have been caused by retinal and vitreous hemorrhages.

B. Heratoconjunctivitis

Five patients stated they had symptoms of bilateral keratitis (photophobia, lacrimation, foreign body sensation) coming on within the first day after the explosion, and lasting two to three days. These were presumably due to ultraviolet radiation. In one other patient with similar symptoms the condition lasted three weeks, but inasmuch as this patient also had extensive burns of the face, it was possibly a thermal injury rather than abiotic. Six patients also gave a history of keratitis coming on 3 to 4 weeks after the explosion and lasting for several days in one patient, and one or more months in the other patients. All of these patients had symptoms of radiation sickness, and the cause of the keratitis was presumably the ionizing radiations.

C. Lenses

Abnormalities of the lenses were noted in 20 patients of this series. Eight had senile cortical cataracts. Seven had congenital opacities situated in the lens nucleus, one had an anterior polar opacity, one had several vacuoles in the anterior cortex and five had posterior capsular cataracts which were believed to have been caused by radiation from the atomic bomb. These will be discussed subsequently together with the cases of radiation cataract in Group II.

There were five additional patients who showed changes in the posterior capsules suggestive of the radiation type but which were insufficiently definite as yet to justify the diagnosis of radiation cataract. One patient<sup>28</sup> had minimal posterior cortical opacities in the axial region of both eyes with two vacuoles beneath the anterior capsule of the right eye. This patient had had no radiation sickness

<sup>28</sup> H.P. No. 282584

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but did have complete epilation of scalp hair beginning, allegedly, three months after the atomic bomb and lasting three months. It seems altogether likely that this is an instance of incipient radiation cataract. Another patient<sup>29</sup> showed a faint axial opacity in the right eye over a 1 mm zone with two scintillating reflections (possibly vacuoles) just in front of the posterior capsule of the right eye. The anterior capsule was normal. The left eye, which apparently had an injury or ulcer of the cornea, showed an opacity of the lower nasal quadrant of the cornea and a posterior synechia, but the lens was clear. The patient had had no radiation sickness but had been almost completely epilated for four months. This is also thought to be a possible instance of early radiation cataract but, if true, the unilaterality of the posterior capsular opacity is surprising. Three patients<sup>30,31,32</sup> showed either haziness and irregular reflexes from the posterior capsule or a few subcapsular vacuoles that were thought to be borderline abnormalities. These patients will be examined again at a later date.

D. Neuroretinal lesions

Two patients in this group had bilateral macular degeneration and one had unilateral macular degeneration. One other patient had a unilateral coloboma of the choroid; one patient had retinitis pigmentosa; one patient had optic atrophy of undetermined origin; and three patients had mild hypertensive and arteriosclerotic changes in their retinal arteries.

E. Miscellaneous ocular findings

Four patients in this group were noted to have shown trachoma and one patient had had a perforating injury of the eyeball.

F. Non-ocular findings

Burns of the face which were sufficiently severe to result in loss of skin occurred in only ten patients of this series. In the two kilometer survey group the incidence of comparable burns was more than five times as great, a difference which is undoubtedly explained by the fact that almost all of the survivors within the one kilometer range had some form of shielding as far as the thermal effects of the bomb were concerned.

On the other hand, the percentage in the one kilometer group who were epilated was much greater than in the two kilometer group (see graphs in Addendum). Sixty per cent were recorded as completely epilated in the one kilometer group, whereas it was only slightly more than four per cent for the two kilometer group. The duration of the epilation in those in whom it was said to have been complete was less

29	M.F. No. 244911
30	M.F. No. 261442
31	M.F. No. 231827
32	M. F. No. 231826

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than one month in 8; from one to two months in 25; from two to five months in 49; from five months to one year in 18; and, allegedly, longer than one year in 12. The duration was not known in 9.

The difficulty in evaluating radiation sickness has already been discussed. Of the 231 patients in this series 205 gave a history of delayed malaise, gastro-intestinal symptoms, or pharyngitis which might be interpreted as radiation sickness. One hundred and nineteen gave a history of petechiae coming on within the first few weeks after the explosion.

Group II. This group was made up of persons who were contacted through local ophthalmologists, through newspaper publicity, or through hearsay. It is therefore a highly selected group, and the incidence of disease in this series gives no indication of the frequency in the population at large. In only a small number was there thought to be any causal connection with the atomic bomb.

The cases seen who gave no history or findings suggestive of association with the atomic bomb are listed according to diagnosis as follows:

Normal	101
Lids and lacrimal apparatus	
Dacryocystostenosis	1
Ectropion (upper lid)	1
Trichiasis (epiblepharon)	4
Trichiasis (trachoma)	1
Chalazion	1
Trachoma (active)	3
Vernal conjunctivitis (lids)	3
Extraocular muscles	
Nystagmus	2
Strabismus	3
Chronic progressive ophthalmoplegia externa	2
Conjunctiva and cornea	
Catarrhal conjunctivitis	3
Vernal conjunctivitis (bulbar)	1
Rupture, Descemet's Membrane (birth)	1
Interstitial keratitis	5
Phlyctenular keratoconjuncti- vitis	1
Leucoma	1
Sclerokeratitis	1

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Lens

Senile cataract	4
Diabetic cataract	1
Coronary cataract	1
Nuclear sclerosis	1
Secondary cataract	1
Congenital cataract	1
Exfoliation of lens capsule	1

Retina and optic nerve

Central serous retinopathy	1
Macular degeneration	1
Separated retina	2
Retinitis proliferans (Eales' disease)	1
Retinitis Pigmentosa	3
Retinitis punctata albescens	1
Optic atrophy (probably methyl alcohol)	2

Uvea

Iritis	3
Uveitis	1
Harada's disease	1

Eye as a whole

Ametropia	16
Chronic glaucoma	2
Phthisis bulbi	1
Congenital microphthalmos	2

The patients in the non-survey group who were believed to have had lesions resulting from the atomic bomb are discussed in the following paragraphs, arranged according to the headings used in the description of the survey cases. It should be borne in mind that the evidence that the lesions in this group were in fact due to the atomic bomb depended on time relationships and morphologic characteristics, rather than on comparative statistics.

A. Subjective visual disturbance.

The only patient falling into this category in the non-survey series was a thirty-year old man who was on the sixth floor inside a concrete building 450 meters from the hypocenter at the time of the explosion. Except for a mild burn of the ear, he had no symptoms until approximately three weeks after the explosion when he became blind. At the same time he developed profound epilation and radiation sickness, (including petechiae). His vision gradually returned two months

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later. At the time of the present examination, vision was 20/30 O.U. and the only objective findings were the presence of flocculent opacities in the lens having a lamellar distribution similar to that seen with congenital cataracts.

The cause of blindness in this patient is not evident but it was obviously part of the radiation syndrome. The present cataracts are considered unrelated to the rest of the condition since similar changes are seen not infrequently in Japanese persons, and there were no changes in the posterior capsule such as occur with radiation cataracts.

B. Keratoconjunctivitis

While several patients in the non-survey group gave a history of a transient keratitis following the atomic bombing, only one showed residual opacities of the cornea thought to be attributable to it. This patient, previously reported by Oyama<sup>33</sup>, was a 23 year old girl who was 2,000 meters from the hypocenter gazing into the sky at the time of the explosion. She was knocked down by the blast but does not remember any visual disturbance until 30 minutes later when her lids became swollen from burns of her face and she could not see. For several days she had pain in the eyeballs, and the photophobia was severe. She was hospitalized for a month with disappearance of the photophobia but was not examined by an ophthalmologist. She had no epilation, diarrhea or fever. When examined two months after the bombing, she was found to have symmetrical opacities of the lower halves of both corneas. The distribution of the opacities was likened to a mountain with a rounded, sharply demarcated upper edge extending into the pupillary area and a less well defined lower edge. The pupils were round and the lenses were clear. The retina and visual fields showed abnormalities to be described subsequently.

The patient was examined by us four years after the bombing and showed superficial and deep opacities in the lower portions of both corneas. They could just be seen grossly as patchy opacities but were conspicuous by slit lamp examination. In other respects the eyes were normal.

C. Lens changes

Ten cases of cataracts thought to be due to ionizing radiation were seen<sup>34</sup>. Five of them were patients in the 1000 meter survey series. Two of the patients, including one who was also contacted in the survey group, were referred to us by Dr. Ikui and one was contacted through Dr. K. Hirose<sup>35</sup>. Two other patients were seen by us because of their complaints of failing vision, (one was an employee of the ABCC!) and the tenth person, who had no visual complaint, was called in because she was known to have been with one of the other nine at the time of the explosion.

33 Oyama: Ganka Kinsho Iho, #40, 177, 1946

34 Protocols of each case are given in the accompanying addendum.

35 This case is being reported at the Kyushu Ophthalmological Society meeting at Kumamoto, Sept. 23, 1949.

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Nine of the patients were exposed at Hiroshima and one of the patients at Nagasaki. All were said to have had normal visual acuity prior to, and for some time after, the bombing. Seven were males and three were females. The ages at the time of the exposure were 13 to 55 years. All were within 550 to 950 meters of the hypocenter at the time of the explosion. Three were standing together in the forward part of a street car. Four were in wooden houses roofed with tile. One was crouching behind a wooden building; one was walking in the street, shielded by the plastered wall of a building; and one is not known to have had any shielding. Two had thermal burns of the profile type (that is, due to radiant heat); all had epilation of the head after a latent period of one to four weeks, with complete baldness lasting three to five months. Six had vomiting on the day of the explosion, and eight had symptoms one to three weeks after the explosion consisting of fever and malaise with vomiting and diarrhea in five and petechiae in five. One developed a sloughing lesion of the buccal mucosa and another a localized necrosis of the cheek with perforation. Whether these were due to radiation sickness or to the unsanitary conditions prevailing at the time could not be determined. One of the three female patients had had amenorrhea since the exposure and the other two began their menses at ages 17 and 19 which was approximately three years after the exposure.

The only ocular complaint of the patients was failing vision. The onset of subjective visual symptoms was said to have been as early as one month after the bombing in one patient, but the patient was in an apprehensive mental state at the time and it is by no means certain that this initial complaint was due to incipient cataracts. The latent period of visual symptoms in seven other patients was: 6 months, in one patient; 2-1/4 years in one patient; and 2-1/2 years, in five patients. Three patients had had no ocular complaints. The failure of vision was said to have been either gradual or step-wise and fluctuant in the seven patients, one of these patients having thought some improvement followed each loss.

The cataracts consisted of opacities in the axial zone of the posterior lenticular capsules over an area of 2 to 4 mm with occasional punctate dots farther toward the periphery. The findings were approximately symmetrical in the two eyes. The central opaque discs had jagged but nevertheless relatively sharp edges. In the five patients in whom the changes were most marked, the peripheral portions of the opaque discs were denser than the central portions, forming doughnut-shaped opacities when examined with the ophthalmoscope. With the slit-lamp biomicroscope the opacities were of a lace-like texture having a few polychromatic crystals and a few vacuoles. The opacities were confined to the posterior capsules with no apparent extension into the underlying cortex but the vacuoles were situated just in front of the capsules. In the two most advanced cases there was a distinct separation of the opacity centrally into two laminae from front to back with a relatively clear interval between them. Toward the periphery of this central disc the two laminae fused to form the denser ring that had given rise

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to the doughnut-shaped opacities seen with the ophthalmoscope. In the less advanced cases which did not show the doughnut configuration, the central portion showed an opacification of the whole thickness of the posterior capsule similar to the peripheral portion of the disc in the more advanced cases. Thus it appears that progression of these cataracts is accompanied by a separation of the central opacity into two layers, separated by a clear interval, and an extension of the unsplit opacity toward the periphery. The anterior capsule also showed a few punctate dots in seven of the patients and an occasional vacuole in three. The lens cortex and nucleus, however, was entirely clear in all cases.

The cataracts are considered to be similar to those which have previously been associated with exposure to x-rays and gamma rays<sup>36</sup>. What part neutrons played in their pathogenesis is not evident. The patients were in a zone where neutrons and gamma rays were present, although information on the amounts of each is not publicly available. Most persons in this zone died either from thermal or mechanical injuries or from radiation sickness. That these persons survived and developed cataracts may have been due simply to biologic variations; but it cannot be reasonably denied that while the cataracts were due to exposure of the head region, the absence of lethal radiation disease may have been due to a shielding of much of the rest of the body. Five of the patients had very little, if any, radiation sickness and it is not impossible that the symptoms in the others may not have been due to radiation. Yet all of them had profound epilation of the head which was undoubtedly a radiation effect. It is possible that the three standing in the front of the street car were protected in the lower halves of their bodies by the metallic baseboard below the car windows.

Aside from the foregoing cases with outright posterior capsular cataracts, several border-line cases were seen that were thought not to represent radiation cataracts but in which final judgment will be postponed until further examination, six months or one year hence. These cases represented an unusual amount of marking of the posterior capsules and none showed opacification that was visible by ophthalmoscopic examination.

Aside from these cases which are thought to be normal variants, a few cases were seen showing abnormalities in the posterior capsule but nevertheless not thought to be due to radiation. One patient was a 17 year old diabetic boy who had been 2000 meters from the hypocenter at the time of the explosion and had had no burns, epilation nor radiation sickness. Examination at the present time showed diffuse opacification of the posterior capsule and anterior capsule in the axial regions and extensive bluish white opacities in the anterior and posterior cortex of both lenses. The presumptive diagnosis was diabetic cataracts.

<sup>36</sup> Rehrschneider, W.: Arch. fur Augen. 106: 221-254, 1932

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The normal posterior capsule may be likened to a layer of glass immersed in water containing a varying amount of etching of its surface. The etching is usually most evident in the axial or periaxial region and can be seen by focal illumination as dots and thread-like lines. Often they are arranged like the tracks made by wild-blown beach grass on the otherwise smooth sand. They are most evident on the posterior surface of the capsule and presumably represent remnants of the hyaloid system. By transillumination, the posterior capsule often shows optical irregularities in the axial and periaxial regions similar to the "warts" on the posterior surface of the cornea.

#### D. Neuroretinal Abnormalities

Approximately 10 persons gave a history of having been gazing at the sky, some at the airplane and at least one at the parachute carrying the bomb, at the time of the explosion but only one person showed any possible evidence of retinal or nervous system damage. This patient<sup>37</sup>, the same one who was previously referred to with keratitis, was a 23 year old girl who had been 2,000 meters from the hypocenter at the time of the explosion and gazing skyward but does not know whether or not it was in the direction of the bomb. At first there were no visual disturbances. When examined two months after the bombing there was a grayish white opacity one-third the size of the disc just temporal to each fovea. By campimetry a central scotoma was found, most dense in a ring-shaped area occupying the 6 to 8 degree isopters. It was symmetrical in the two eyes. The visual acuity, which was known to have been normal before the bombing, was correctible to O.D. 0.6 (20/50) and O.S. 0.9 (20/30). Examination four years after the bombing showed similar bilateral ring-shaped scotomata, but there were no abnormalities found in the fundus.

This patient is presumed to have had an infrared burn of the retina and was the only patient seen on whom such a diagnosis we made.

One other patient in the non-survey series had retinitis proliferans in one eye. The patient is said to have lost her vision in this eye immediately after the atomic bomb, presumably from a vitreous hemorrhage, although there was no known trauma.

#### E. Miscellaneous Ocular Findings

Perforation of the globe, frequently with loss of the eye, or phthisis bulbi, was seen in 21 cases, in four of whom it was bilateral. In practically all cases the injury was caused by glass and in many cases it was accompanied by multiple scars of the lids and face. For some reason which is not apparent, these scars often had a distinct blue color. That it was glass, rather than any inherent characteristic of the scar formation that caused this discoloration is suggested by the fact that burn scars and surgical scars in the

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<sup>37</sup> Previously described by Oyama in Ganka Rinsho Iho, Vol. #40, 177, 1946.

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Japanese show no similar pigmentation. The possibility that the discoloration was simply due to dirt that had been carried into the wounds could not be excluded, but its uniformity and the absence of granular texture made this possibility unlikely.

Iridodialysis resulting from the bomb was seen in one patient and is presumed to have been due to a blow with some blunt object rather than to the blast.

Two persons who had had evidence of brain injury at the time of the bomb had complicating eye signs, one with bilateral sixth nerve paralysis and one with optic atrophy.

Pupillary areflexia was found in one eye of a patient who had been blind for several days after the explosion. She is presumed to have had an intraocular hemorrhage at the time.

### III. General observations on Japanese eyes

Since, to our knowledge, no comparable examination has been reported on a large number of normal Caucasian eyes, the following observation may have little comparative significance. The data is, therefore, not presented statistically, but rather as our impression of certain differences between Japanese eyes (presumably applicable to all Orientals) and Caucasian eyes.

Trichiasis in association with epiblepharon is so frequent in Japanese children that it may be considered a normal variant. The responsible lashes are usually those in the inner portion of the lower lid and produce keratitis and occasionally pannus in the lower nasal quadrant of both corneas. It is not accompanied by scarring of the lids or by entropion. The subjective disturbances caused by the trichiasis are variable but it was noteworthy that there was no case in which these symptoms were as marked as might be expected, and often there were no symptoms at all. In view of the fact that the condition was found almost exclusively in children, it is presumed that it becomes outgrown.

Staphylococcal and rosacea keratitis was conspicuous by its rarity in comparison with our experiences in the United States. Acne of the face also appeared much less common. Trachoma, on the other hand, was frequent, being present in 5% to 10% of the cases examined. Pterygia and conspicuous pinguecula were perhaps somewhat more frequent than in at least some parts of the United States (Northeast) and it appeared that the pinguecula were situated closer to the limbus than is the case with Caucasian eyes, often actually over-riding the cornea. One case of incipient pterygium in a heavily pigmented eye is perhaps especially noteworthy because of its possible significance in the pathogenesis of pterygia in general. Just in advance of the spearhead of the pterygium was 1 mm zone of flat pigmented epithelium suggesting that epithelium had grown over from the limbus in advance of the pterygium.

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Vernal conjunctivitis of both bulbar and palpebral type appeared more common than in a comparable group in the United States.

Evidence of arteriosclerotic or hypertensive vascular disease was rare, but Eales' disease in young persons was relatively frequent. Only two instances of primary glaucoma were seen and by inquiry among ophthalmologists this seems to be relatively infrequent in Japan.

Probably occurring in Caucasian eyes also, but being less evident, is the depigmentation of the pigment epithelium of the fundus with age and with high myopia. This leads regularly in the seventh decade to an exaggeration of the tessellated appearance of the fundus.

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Summary and Conclusion

Previous reports of ocular lesions resulting from the atomic bomb have been concerned chiefly with traumatic injuries and retinal complications of radiation sickness. The present study was undertaken with the prime motive of determining what, if any, delayed injuries to the eyes had resulted from the atomic bombing.

Accordingly, 1,000 persons who were listed as having been in the "open" and within two kilometers of the hypocenter at the time of the explosion were selected at random from the census files of the Atomic Bomb Casualty Commission for study. In addition, 231 others, comprising the total available number of surviving persons listed at present in the census files as having been within one kilometer of the hypocenter, were examined, as were several hundred others who were contacted through newspaper publicity, referrals from local ophthalmologists, or through hearsay.

The survey resulted in bringing in persons having, or having had, a variety of ocular conditions. Those connected with the atomic bomb included the following diagnoses: multiple injuries of eyes and eyelids, keratoconjunctivitis from ultraviolet and ionizing radiations, thermal burn of the cornea and of the retina, retinitis proliferans, and radiation cataracts. The cataracts were the only delayed manifestations of ocular injury from the atomic bomb.

Ten cases of radiation cataract were found. They all occurred in persons who were within one kilometer of the hypocenter and who were either in the "open" or protected by a wood or plaster wall. All had a delayed loss of their entire scalp hair but did not necessarily have radiation sickness. The ages at the time of exposure were between 13 and 55. Three were females and six were males.

The lens changes consisted predominantly of granular opacification of the posterior capsules in the axial zone. The mildest cases showed simply an asterisk-shaped central opacity, not more than 1 mm. in diameter, having several subcapsular vacuoles. The more marked cases showed, with the ophthalmoscope, a discoid opacity of the posterior capsule, having a characteristic doughnut shape with a relatively more translucent zone in the central three to four mm. region. With the slit lamp biomicroscope the opacity was seen to be made up of granules forming a lace-like pattern and containing many scintillating highlights and occasional polychromatic reflections. In the more marked cases the opacities appeared to be split from front to back with a relatively clear lamina between the opaque layers. This clear lamina, which had a thickness equal to or several times that of the posterior capsule, was generally seen in the region corresponding to the translucent portion of the doughnut. In the early cases, before the lamination occurs, the greatest opacification of the capsule is to be found axially, but as the splitting takes place the greatest opacity extends progressively toward the periphery, forming the characteristic doughnut-shaped reflex. Whereas the posterior opaque lamina coincides with the posterior surface of the lens, the anterior lamina may bulge forward but it is nevertheless sharply demarcated from the underlying cortex. It does not show the extension into the cortex which is seen

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with the usual cataracta complicata and posterior polar cataracts. Vacuoles situated just beneath the posterior capsules are frequently found even in the mildest cases.

With the more advanced changes, fine opacities are also to be found in the anterior capsule and in the anterior subcapsular zone. Here they are often accompanied by vacuoles.

The latent period for the subjective disturbances resulting from the cataracts is usually two years. The progress is slow and sometimes step-wise. Objective findings may antedate the subjective findings. The frequency of radiation cataracts is at present of the order of 2-1/2 percent of survivors within the one kilometer zone, but since the latent period may be many years, it is obvious that the frequency may increase considerably in the years to come.

The occurrence of radiation cataracts is thought to be significant not only on account of their ocular implications but more especially because they are the first delayed effects of the atomic bomb to have been demonstrated in the body as a whole.

#### Recommendations

1. Having established the fact that radiation cataracts resulted from the atomic bomb, it would now appear desirable to obtain information on their time of onset and course. Since it appears that the cataracts occurred exclusively within the one kilometer zone, attention should be directed to this group. As many persons as possible within this zone should have an ophthalmic examination now, both at Hiroshima and Nagasaki, and a survey of these same patients should be made in two to three years to determine how many have developed lens changes in the meantime. For the two kilometer zone, the patients already examined should suffice to form a base line for a subsequent survey.
2. The ten patients who have been diagnosed as having radiation cataracts and the nine patients who were thought to have suggestive lens changes should be observed at not more than six-month intervals for progress study.
3. It is suggested that Dr. H. Ikui be appointed Japanese consultant to ABCC on problems in ophthalmology.

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ADDENDUM I

Ophthalmologic Survey of Atomic Bomb Survivors in Japan  
November 1949

Cataract Case #1

H. K.<sup>1</sup> Patient was a 20-year old girl who, at the time of the Atomic Bomb explosion was standing in the forward part of a street car directed toward, and at 850 meters from, the hypocenter. The window of the street car is believed to have been open at the time. The patient was knocked over by the blast and was unconscious for about 10 minutes. She recalled having seen a flash of light but had no recollection of a sense of heat. When she recovered consciousness, she was aware of a "yellow dust" everywhere, but the patient believed her eyes were normal. Of the patient's two companions who were with her at the time of the explosion, one died in four days' time and the other is the patient listed as "Cataract Case #2" in this series.

This patient's face was extensively burned over the left forehead and cheek, including the scalp hair, brow, and eyelashes on the left side and the patient had a considerable thermal burn corresponding to the part. All burned areas healed in two months' time.

Within the first day after the bomb, the patient began to have vomiting and thirst lasting one week and fever (40° C) lasting one month.

Approximately one week after the explosion, the patient began to lose her scalp hair, and in the course of two weeks time she became completely bald and remained so for five months. The patient does not believe there was any delayed loss of eyebrows or eyelashes.

In three to four weeks after the atomic bomb, the patient developed malaise, fever, diarrhea, bloody stools, and bleeding from the gums. She was sufficiently ill at that time and subsequently to remain in bed for four months. The patient had no complaint referable to the eyes until 2½ years after the explosion, and periodic examination at school prior to this time showed that the patient had continuously normal visual acuity. The patient then began to notice painless loss of vision which was gradually progressive for one year but since then has remained stationary to the time of the present examination, that is, for the past six months.

The patient's menses began at 19 years of age and have been regular since.

Examination of the eyes showed no abnormality other than that in the lenses. Visual acuity was: O.D. (with - 3.50 sphere) 20/20<sup>-3</sup> and O.S. (with - 3.00 sphere) 20/40<sup>-3</sup>. Prior to the development of cataracts the patient had not been myopic.

By ophthalmoscope, axial opacities approximately 4 mm. in diameter were visible in a posterior part of both lenses. That in the right eye had a speckled appearance, greatest centrally and diminishing peripheral-wards, that in the left eye had a doughnut shape with maximal density in

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<sup>1</sup> H.F. No. 400584

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a ring-shape zone approximately 4 mm. in diameter. By slit-lamp biomicroscopy there were fine punctate opacities and an occasional vacuole immediately beneath the anterior capsule. The most marked changes were in the posterior zone of the lenses, apparently in the capsules, and consisted of a massing of granules, some of which were scintillating and a few of which were polychromatic. These were most marked centrally and faded out peripheralward but were detectable to some extent as far as could be seen in the slit-lamp beam. The cortex and nuclei were entirely clear and showed no unusual reflectivity of the lenticular laminae. There was no reduplication of the posterior lens such as occurred in several other patients of the present series.

Cataract Case #2

A.A.<sup>2</sup> The patient was a 19-year old girl, companion of the preceding patient. At the time of the explosion, the two were standing side by side in the forward part of street car directed toward, and at 850 meters from the hypocenter. She was wearing the Japanese mōmpe at the time and received no burns other than that of the face and left arm. Her eyes were said to have been sore after the bombing, but the swelling of the face for the first week or so masked the ocular signs. After one week, the patient developed fever (40° C) and bleeding from the gums, lasting for one week, but no diarrhea or petechiae. Approximately two weeks after the atomic bomb, she began to lose her scalp hair, and within a few days she became completely bald and remained so for six months. Her eyebrows and eyelashes had been lost by the flash burn. The patient's menses began at the age of 17, two years after the explosion.

Except for the first few days, the patient had no subjective ocular symptoms. She reported for examination only on request and believed her eyes to be normal. Her visual acuity without correction was:

C.D. 20/20<sup>+3</sup>; C.S. 20/15<sup>+3</sup>. The only abnormalities evident in the eyes were in the lenses. By ophthalmoscopic examination there was an axial opacity in the posterior part of both lenses occupying a 2 mm. zone and having jagged but well defined edges. A few punctate dots could be seen outside of this central zone. By slit-lamp biomicroscopy this opacity was seen to be in the posterior capsule, occupying the whole thickness of the capsule in the axial region and occupying the anterior and posterior faces of the capsule in the periphery of the opacity. Thus a relatively clear layer between the two opaque laminae could be made out in places. There were occasional polychromatic crystals in the opacity and a few vacuoles just anterior to the posterior capsule; these appeared to separate the capsule from the cortex. The anterior portion of the lenses showed several fine punctate opacities immediately beneath the capsule, but no vacuoles.

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Cataract Case #3 (Referred by Dr. H. Ikui)

T.H.<sup>3</sup> The patient was a 21 year old man who was also in the forward part of the street car in which the previous two patients were standing, at 850 meters from the hypocenter. He was apparently standing just behind the other two. He was dazzled by the flash of light and his glasses were blown off by the blast but he was not knocked down and did not lose consciousness. He received no burns but did have multiple lacerations from flying glass particles. However, his injuries were not so great but that he was able to remain for approximately 15 minutes to help extricate the injured, and only then fled on account of the fires. Within a few hours, however, he developed extreme thirst, nausea, vomiting, diarrhea, and weakness. These symptoms persisted for about two weeks.

Two weeks after the explosion his hair began to fall out, and within three days' time he was completely bald. His hair began to return seven weeks later.

Three weeks after the explosion he developed some petechiae and a fever (40° C) and malaise which continued for ten days. The mucous membrane of the mouth turned white and sloughed off. There was severe aching of the teeth where they were exposed by the loss of the mucous membrane.

The patient then developed a severe diarrhea, with offensive odor to his stools, which persisted for several weeks.

While receiving vitamin injections, he developed multiple boils at the sites of injection.

Four months after the explosion, the patient developed some sort of conjunctival discharge that persisted for one month. He had had his eyes examined three days prior to this and the eyes were said to have been normal. A white blood cell count taken at this time was 6,000.

Except for the above, the patient had no complaint referable to his eyes until approximately two years and three months after the bomb, when he began to have difficulty in reading, especially in the sun. Three months after the onset, he was told by an ophthalmologist that he had posterior polar cataracts, but the visual acuity in each eye was 1.2. Vision deteriorated rapidly thereafter, and six months after the onset acuity was O.D. 0.1 (20/200) and O.S. 0.01 (2/200). At this time Dr. Ikui examined him and found in both eyes a powder-like opacity under the posterior capsule which, by reflected light, looked like the surface of mica. Two months later the posterior subcapsular opacity had increased, and the visual acuity was O.D. 0.05 (10/200) and O.S. 0.04 (8/200).

Examination at the present time, four years after the explosion and two years after the onset of the visual complaint, showed the following:

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By ophthalmoscopy, the lens of the right eye showed an ill-defined axial opacity about 4 mm. in diameter situated in the posterior part of the lens and surrounded by punctate opacities diminishing toward the periphery. The left eye showed an opacity of similar size and type but having a distinct doughnut shape with a relatively clearer zone in the center. By slit-lamp biomicroscopy of the right eye, there were a few punctate opacities and a few vacuoles in the anterior sub-capsular region and many tinsel-like opacities and an occasional vacuole within the capsule in the central area over a 4 mm. zone and a few dot-like opacities in the environs. The left eye showed similar findings, but the doughnut-shaped distribution of the opacities seen ophthalmoscopically was less evident with the biomicroscope than it had been with the ophthalmoscope.

The fundi were well seen through dilated pupils, and the rest of eyes was entirely normal.

Cataract Case #4 (referred by Dr. H. Ikui)

U.S.<sup>4</sup> The patient was a 23 year old man who was in the open and 700 meters from the hypocenter at the time of the explosion. He was aware of the flash of light and was then pinned under a falling building. Whether or not he was shielded from the bomb is not known, but he received no thermal burns and is therefore believed to have been shielded by a wooden house. During the first 24 hours he had no appetite and vomited several times but was otherwise well.

Wineteen days after the bomb, the patient began to lose his scalp hair, and within one week he was completely bald. On the twentieth day after the bomb, the patient developed petechiae and a cough, with bleeding from the nose, gums, and throat. There was, however, no diarrhea. The patient was treated with intramuscular injections of his own blood. The bleeding stopped by the 27th day. No leucocyte count was done. The hair gradually returned on his head and was said to be normal in five months time.

The patient was not aware of any visual difficulty until 2½ years after the atomic bomb when it was found that his visual acuity could not be improved by glasses. He had no ophthalmological examination until seen by Dr. Ikui four years after the atomic bomb, at which time the findings were the same as recorded by us one month later.

Examination shows the following:

By ophthalmoscopy of the right eye, a star-shaped opacity was evident in the posterior part of the lens, its central portion being approximately 2 mm. in diameter and one portion of the opacity extending approximately 2 mm. from the center. There were also fine punctate opacities extending toward the periphery. The left eye was practically identical. In neither eye was there a doughnut shape to the opacity.

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By slit-lamp biomicroscopy there were several punctate subcapsular opacities and occasional vacuoles in the anterior cortex of both lenses. The most conspicuous abnormalities were in the posterior capsule (not cortex) where there were tinsel-like opacities in a 3 mm. zone, more or less star-shaped, and several vacuoles in the eccentric portion of the opacity. In neither eye was there a splitting of the opacity into two laminae.

The patient was seen again one month later because visual acuity in the right eye had decreased to 0.4 (20/70) (it was still 0.8 (20/30) in the left eye). Examination showed the same type of opacity as noted previously and possibly some increase in the opacity of the right eye.

Cataract Case #5

T.F.<sup>5</sup> The patient was a 17 year old boy who was at the Nagasaki Technical School at the time of the bombing (550 meters from hypocenter), sitting against a wooden building on the side away from the bomb. Of the 100 or so students, all but possibly one other are believed to have been killed. Following the explosion, the patient had photophobia for two to three minutes. He received no burn, but the building fell on him. He was able to extricate himself and flee. There was no loss of consciousness.

Two weeks after the bomb the patient began to lose his scalp hair and he became completely bald within a few weeks. There was slight, if any, loss of eyebrows and none of cilia. His head hair began to grow back in three months' time but was white and later is said to have fallen out again.

Three weeks after the bomb explosion, the patient developed malaise, fever, swelling of the face and a sore that "rotted" through his cheek.

The patient was hospitalized at Oshima Coal Mining Hospital where the blood count is said to have been low.

The patient denied any foreign body sensation in his eyes after the bombing, either immediate or delayed. Although in a technical school, the patient had had no contact with x-rays and gave no history of electric shock.

The first difficulty with the eyes was noted about six months after the bomb when he couldn't see airplanes in the air. He was examined by an ophthalmologist one year after the bomb, and cataracts were found. The visual acuity at that time was O.D. 0.20 (20/100); O.S. 0.6 (20/70). Acuity gradually became worse, and in June 1949 it was O.D. 0.06 (10/200) and O.S. 0.6 (20/70).

Examination:

O.U. white and quiet. The anterior segments were normal except for the lenses, which showed the following changes in both eyes. The abnormalities were most apparent in the region of the anterior and posterior

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5 M.F. No. - none. Case reported by Hirose, K., Kyushu Ophthalmological Society, Sept. 23, 1949.

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capsules. The anterior capsule showed a granular opacity limited to a central zone not more than 4 mm. in diameter. It was most dense axialward and faded out peripheralward. Within this area there were many polychromatic crystals and an occasional vacuole, but all the changes were limited to the capsule or to the immediate subcapsular zone. The lens cortex and nucleus were clear; there were no evident lens suture lines and no unusual demarcation of the zones of reflectivity. The posterior capsule showed a similarly granular opacity but more extensive than in the case of the anterior capsule. The most marked opacification of the posterior capsule occurred in a zone approximately 5 mm in diameter producing a doughnut-shaped black reflex by ophthalmoscopy. Peripherally there were granular opacities of the posterior capsule extending as far as could be seen. With the narrow beam of the slit-lamp, the central disc-like opacity could be seen to be made up of two laminae fusing at the edge of the disc and separated in the central posterior portion of the disc by a relatively clear zone approximately 0.5 mm thick. The posterior lamina was continuous with the posterior surface of the lens while the anterior lamina was more of a radian. Its anterior face was slightly irregular but nevertheless sharply demarcated from the rest of the cortex. As in the case of the opacity in the anterior capsule, that in the posterior capsule contained many scintillating crystals, but possibly fewer having polychromatic reflections. Considering the possibility that the central relatively clear interval between the two laminae might be the result of fusion of vacuoles to form a fluid zone, special attention was directed toward the presence of vacuoles or a fluid level. Neither was seen.

Cataract Case #6.

H.H.<sup>6</sup> Patient was a 39 year old woman who was walking on the street 950 meters from the hypocenter at the time of the bomb explosion and believes she was shielded by houses and by an open umbrella. The buildings are believed to have been two-story structures with bamboo-mud walls. The patient was thrown to the ground by the blast and was covered with falling debris. She suffered lacerations of her head, wrist, and back but was not burned. She extricated herself from the fallen buildings and fled. Within a few hours, however, she vomited, became very weak, and voided bloody urine.

On account of weakness, the patient went to bed and remained bed-ridden for two months. About one week after the explosion, she developed fever, petechiae over the abdomen, and her hair began to fall out. The epilation progressed to complete baldness, and permanent hair did not return for approximately ten months. The eyebrows are also said to have become thin, but no abnormality was noted with the eyelashes. Visual acuity, which was normal prior to the atomic bomb, is said to have become poor one month afterwards. It is uncertain whether visual acuity

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decreased gradually after that or not, but three years after the atomic bomb she found she could no longer read the newspaper. That was one year prior to the present examination, and there has been no appreciable worsening of vision since. At no time were there symptoms of keratitis.

The only significant abnormality in the history, other than that noted above, is amenorrhea since the atomic bomb.

Examination of the eyes showed no abnormality other than that in the lenses.

Ophthalmoscopic examination showed in both eyes a discoid opacity having a characteristic doughnut shape in the posterior pole of both lenses. These opacities were approximately 4 mm in diameter with a peripheral rim 1/2 mm wide being denser than the rest. The central portion of the opaque area was granular, and several vacuoles could be seen in the outer edge of the disc. There were a few punctate dots outside the disc, but these decreased peripheralwards, and beyond a central 6 mm zone the lenses were clear. There were also fine punctate opacities and vacuoles axially in the most anterior portions of the lenses; these were just visible with the ophthalmoscope.

By biomicroscopy there could be seen 10 - 20 vacuoles and many fine dots in the anterior subcapsular cortex. Some of the vacuoles may have been within the capsule. The posterior capsules showed a diffuse and scintillating opacity corresponding to the central disc seen ophthalmoscopically. With the focussed beam, this opacity could be seen to be made up of two laminae, separated by a relatively clear interval having the approximate thickness of the posterior capsule, and fused at the region corresponding to the outer rim of the doughnut opacity. Several polychromatic particles and a few vacuoles could be seen in the anterior lamina. The opaque laminae were sharply delimited from the overlying cortex, and the rest of the lens was entirely clear.

#### Cataract Case #7

S.F. <sup>7</sup> The patient was a 20 year old boy who, at the time of the atomic bomb explosion, was standing on the street, 800 meters from the hypocenter. He is thought to have been shielded by a wooden house. He was watching the airplanes, which had already dropped their bomb load, when he saw a flash and was knocked unconscious. How long he was unconscious is not known. He received multiple mechanical injuries but no burn. He had some nausea and vomiting during the first three to four days but no delayed radiation sickness. The patient's father, who was with him at the time of the explosion, died 18 days later with multiple injuries and radiation sickness. The patient's brother, who was in the adjacent house, died immediately, and his mother, who was also in the house, died 16 days later from injury and radiation sickness. Epilation had just begun at the time of her death.

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The patient was essentially bed-ridden for six months on account of injuries. He lost all scalp hair and eyebrows, beginning about one month after the explosion, and was bald for five months. However, he had no symptoms of radiation sickness, and eight months after the explosion he was able to return to school.

He had no complaint referable to his eyes until two and one-half years after the explosion when he began to note blurring; vision had gradually failed since that time.

Examination of the eyes at the present time showed the following:

Vision: O.D. 20/200; O.S. 20/200.

By ophthalmoscope, opacities were seen in the posterior part of the lenses of both eyes with maximal density in a small central disc approximately 3 mm. in diameter. This disc had irregular edges and was slightly more translucent in the axial region, forming a doughnut-shaped opacity. There were many punctate opacities radiating out from this central disc to the periphery.

By slit-lamp biomicroscopy, the central disc was made up of a dense posterior portion corresponding to the curve of the posterior capsule and an anterior portion bowed forward with a relatively clearer zone in between. The portion bowed forward was sharply demarcated from the underlying cortex and was much less dense than the posterior portion. Toward the periphery of the disc the anterior and posterior portions became fused into a single opaque lamina which decreased abruptly toward the periphery. The opacity had a granular texture with many polychromatic and scintillating highlights. The anterior capsule also showed many fine opacities in its axial zone and numerous subcapsular vacuoles. There was, however, no opacification of the cortex, and the lens nucleus was entirely clear.

The rest of the eyes appeared entirely normal.

Cataract Case #8

S.Y.<sup>8</sup> The patient was a 59 year old man who, at the time of the explosion, was in a wooden house 690 meters from the hypocenter. The patient believed he was protected by the roof, which was made of tile. He was knocked down by the blast but received no injury and had no abnormal symptoms for the first month after the explosion. Specifically, there was no fever, no unusual diarrhea, no vomiting, petechiae or other evidence of bleeding. There was no photophobia, redness, watering, or foreign-body sensation of the eyes. One month after the explosion he began to lose his hair and was completely bald for two months. There was no noticeable loss of eyebrows or eyelashes.

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The only noteworthy events in the patient's past medical history was gonorrhoea at the age of 20 and chronic diarrhoea for the past several years, both preceding and following the explosion of the atomic bomb. During a period of exacerbation of the diarrhoea, one year after the atomic bomb, the patient was given several treatments in the leg with "kyu". At some indefinite time later, probably several months, the patient is said to have developed painless, non-tender swelling of his knees and progressive difficulty in walking. At the present time he is able to get around only with the aid of crutches.

Prior to the atomic bomb and for some time afterwards the patient's only ocular symptoms were those of presbyopia. Beginning one and one-half years ago, that is, two and one-half years after the atomic bomb, he began to notice diminution in visual acuity, and this has gradually worsened to the present.

Examination: Visual acuity: O.D. 20/200 improved to 20/70  
with pinhole  
O.S. 3/200 improved to 6/200  
with pinhole

By ophthalmoscopic examination, the right eye showed an egg-shaped opacity approximately 7 mm in diameter, situated in the axial portion of the posterior part of the lens. Within this opacity were three relatively clear areas, each about 3 mm in diameter. The edges of the opacity were jagged but nevertheless fairly clear cut. Farther toward the periphery there were many fine dots but no consolidated opacity. Some fine dots could also be made out in the most anterior portion of the lens. The left eye showed an opacity similar to that in the right eye except that the whole axial region was relatively less dense than that of the periphery, forming a characteristic doughnut shape with a central clear area approximately 5 mm in diameter.

By slit-lamp biomicroscopy, the chief opacity was found to be in the posterior capsule or just in front of it and was approximately symmetrical in the two eyes. The opacity consisted of a golden yellow reflex having many scintillating highlights and a few polychromatic crystals. By sharp focal illumination the opacity appeared in places to consist of two laminae separated by approximately the width of the posterior capsule. The anterior lamina had approximately double the amount of the posterior lamina. Situated in or just in front of the anterior surface of the capsule, the opacity showed no appreciable extension into the cortex. The anterior lens region also showed fine opacities in the axial zone. These consisted of punctate dots just beneath the anterior capsule but did not form any consolidated opacity. Nuclear sclerosis was present to some degree in both eyes but was much more marked in the left eye and was sufficient to account for much of the reduction in visual acuity.

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Except for these lens changes and for the lower half of each cornea, which showed considerable keratitis epithelialis, the rest of the eyes was normal.

General physical examination of the patient showed a spastic paraplegia which was presumed to be due to an expanding lesion of the spinal cord or to multiple sclerosis and was probably not related to radiation from the atomic bomb.

Cataract Case #9

S.K.<sup>10</sup> The patient was a 28 year old man who, at the time of the explosion, was on the first floor of a one-story wooden house (tile roof) 870 meters from the hypocenter. He was knocked over by the blast and received some lacerations from glass but no burns. One week later, the patient developed fever, malaise, pharyngitis, and petechiae which lasted about one week. Beginning about two weeks after the explosion, the patient began to lose his hair and was completely bald for three months. His eyebrows and eyelashes are also said to have come out.

Beginning about three weeks after the atomic bomb, the patient's vision is said to have been somewhat blurred for far and near, but this spontaneously improved several months later. Since then, the patient has had no visual complaint, although there has been some increase of his myopia. He reported for the present eye examination as a survey request and not because of any visual symptoms.

The patient's past history was not remarkable except for some childhood difficulty with his leg which had resulted in permanent lameness.

Examination of the eyes at the present time showed the following:

Visual acuity: O.D. with glasses (approximately -3.00 sphere)  
= 20/40; pinhole = 20/30  
O.S. with glasses (approximately -3.00 sphere)  
= 20/50; pinhole = 20/30

Ophthalmoscopic examination showed in both eyes a symmetrical opacity of the posterior pole of the lens measuring not more than 1 mm in diameter. The opacity had the shape of an asterisk, with jagged edges. A few fine dots could be made out in the rest of the cortex, extending out to the periphery, and several vacuoles were seen in the region of the opacity. The opacities did not have the doughnut configuration. Slit-lamp biomicroscopy showed a few fine dots in the subcapsular region of the anterior lens. These were not definitely abnormal. The posterior capsule, however, showed in the axial region a diffuse granular opacity having many scintillating highlights. The edges of this opacity were

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sharply demarcated from the rest of the capsule, but were, none the less, jagged. There were a few vacuoles just in front of the capsule, but the opacity did not extend into the cortex. There was no splitting of the opacity into two laminae as had been the case with some of the other cases. The rest of the lens was clear in each eye, except for a few coronary opacities.

The eyes were otherwise normal.

Cataract Case #10

G.V.<sup>11</sup> Patient was a 45 year old man who was standing beneath the tiled eaves of his house at the time of the atomic bomb explosion. He saw the flash of light and was then pinned under the debris. He was not burned but did receive some injury to his back by the falling timbers. On the day of the bomb he had some nausea and vomiting but no other symptoms until 15 days later when he developed fever, petechiae, nausea and vomiting lasting one to three weeks. About the same time his hair began to fall out and he became completely bald. His hair grew in again seven months later.

The patient had always been myopic (O.U. - 5.00 spheres), but had had no unusual difficulty with his vision since the atomic bomb explosion; although on direct questioning he thought his distance vision was not as good as formerly. He had had no symptoms of keratitis and no awareness of any blurred vision.

Examination: Vision with glasses:

O.D. 19/200 improved with pinhole to 20/50  
O.S. 20/70-1 " " " " 20/50

By ophthalmoscopy there was an opacity at the posterior pole of each lens having the shape of an asterisk and being no larger than 1 mm in diameter. It was not uniformly opaque, being more translucent in some regions than in others. By slit-lamp biomicroscopy the opacities appeared to be made up of powder-like white flecks in the axial region of the posterior capsule with an occasional vacuole just in front of the capsule. The lens cortex and nucleus were normal. There was no opacification of the anterior capsule.

The eyes showed no other abnormality.

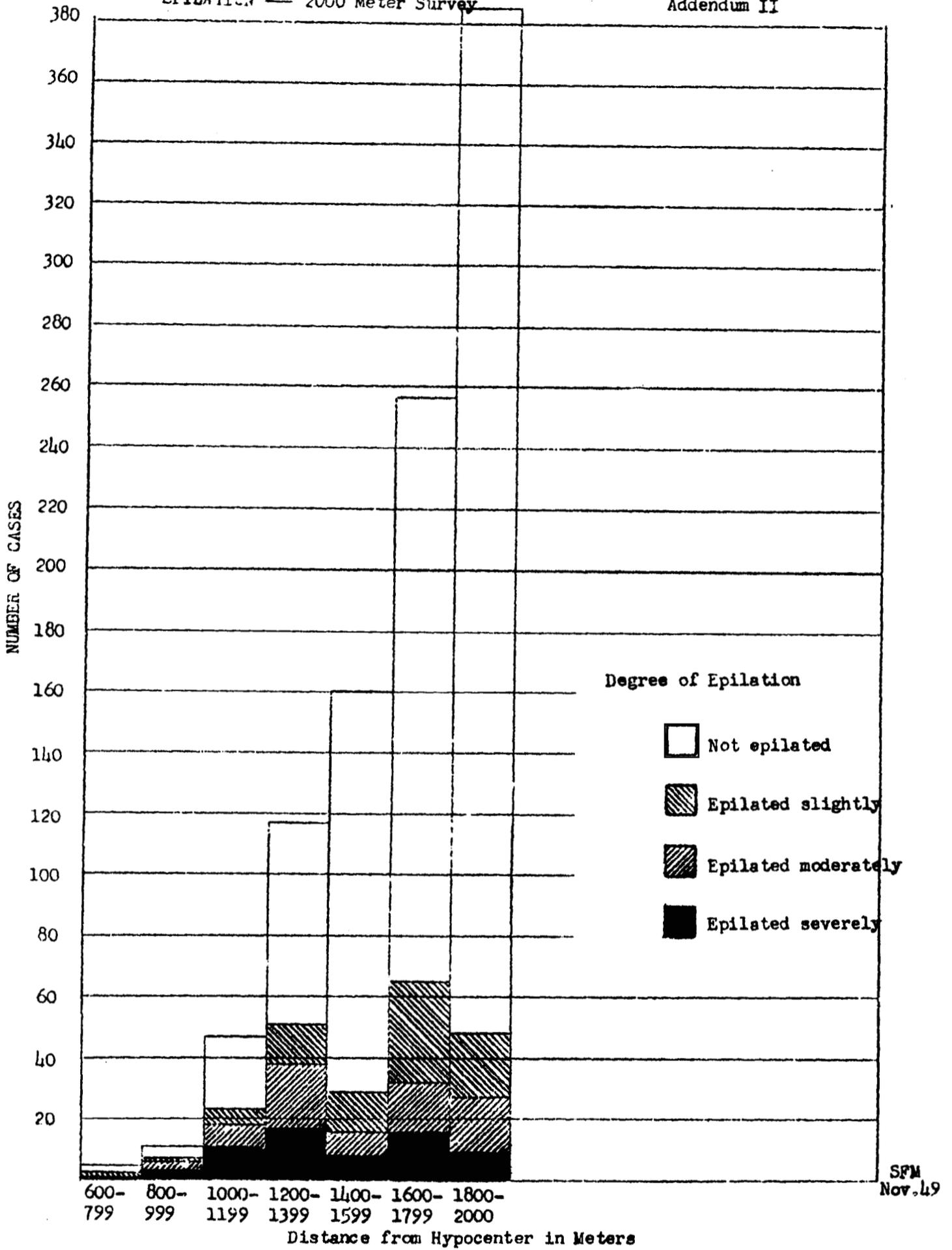
11 K.F. No. 247641

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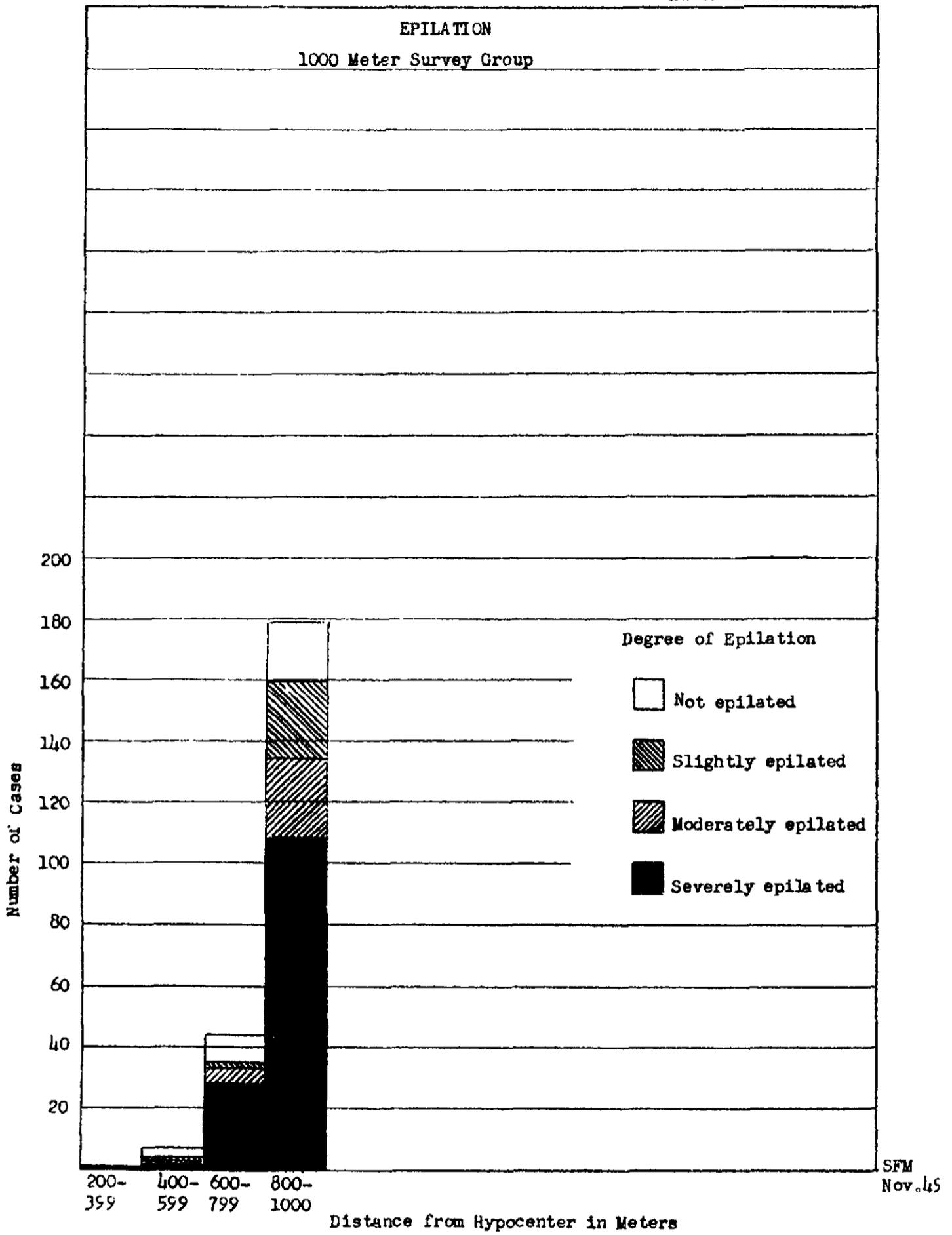
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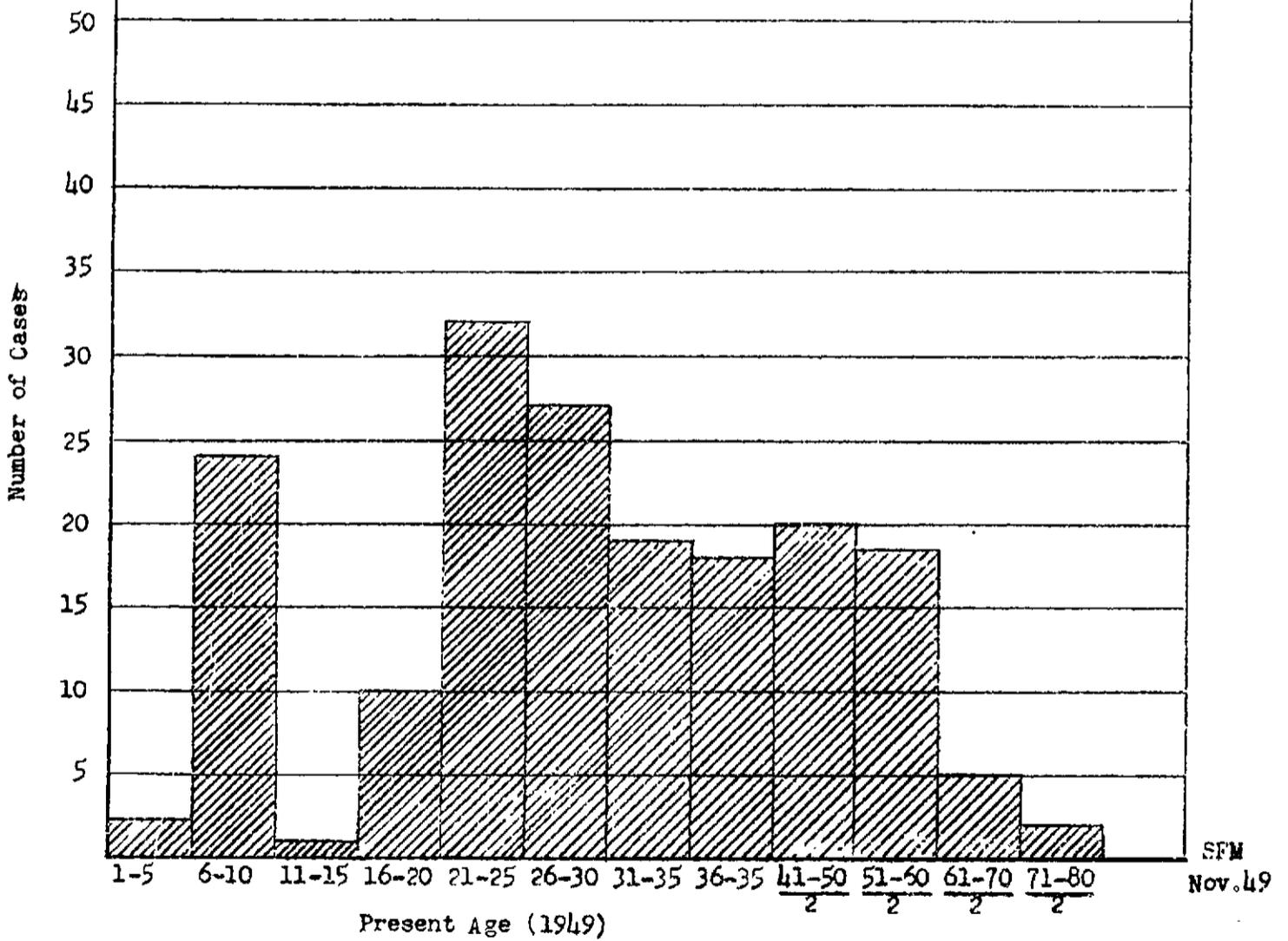
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Distribution by Ages

1000 Meter Survey Group



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Addendum V

ABCC-11  
30-6-49

M-F No.

RADIATION HISTORY

NAME (Kanji) (Romaji) Where Exposed H N

Subjective experience with A. B.

Light  
Heat  
Sound  
Air Blast  
Injury by structures

Injury by fire

Where did you go after the explosion?

Where were you thru the day 6 Aug. 1945?

Where were you thru that week?

Where were you thru the month following?

	<u>Symptoms</u>			<u>Duration</u>	<u>Treatment</u>
	<u>Time of Onset</u>	<u>Degree</u> None Mild Mod. Severe			
<u>Systemic</u>					
Fainting, unconsciousness					
Weakness					
Mental clouding, amnesia					
Malaise					
Fever					
<u>Gastro-intestinal</u>					
Vomiting					
Nausea					
Anorexia					
Thirst					
Bleeding from gums					
Sores in mouth					
Angine, pharyngitis					
Diarrhea					
Bloody stools					
<u>Skin</u>					
Burns					
Petechiae					
Ulcers					
Boils					
Scars					
Epilation					
<u>Eyes</u>					
Change in vision					
<u>Genito-urinary</u>					
Hematuria					
Impotence					

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OP-1  
12-9-49

OPHTHALMIC QUESTIONNAIRE

Dept. No.	Date	M-F No.	Exposed: Yes No	
Name: (Kanji)	(Romaji)			
I.	Were you watching the B-29 when the bomb went off?	Yes No		?
II.	Did the A-Bomb blast knock you over? If so, were you knocked unconscious?	Yes No Yes No		
III.	Was there loss of hair? eyebrow? eyelashes?	Yes No Yes No Yes No		?
IV.	Was there burn of face? (redness, blisters, loss of skin)	Yes No		?
V.	Were any of the following symptoms present: a. Foreign body sensation in the eyes, Present in both eyes b. Sensitivity of light, Present in both eyes c. Tearing, Present in both eyes d. Redness? Present in both eyes	Yes No or one eye? Yes No or one eye? Yes No or one eye? Yes No or one eye?		
Time of onset and approximate duration. Had patient had similar symptoms prior to August 6th 1945? Yes No				
VI.	Was there a period of blindness (partial ___ or complete ___) following the bomb. If so, state time of onset and duration. Present in one ___ or both eyes _____. Describe in patient's words.			
VII.	Have you been treated by an eye doctor either immediately following the bombing or since? If so, give name and approximate address?	Yes No		
VIII.	Do you know of any eye disease which you have?	Yes No		

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OP-2  
12-9-49

EYE EXAMINATION

Dept. No.	Date	M-F No.
Name: (Kanji)	(Romaji)	Exposed: Yes No
VISION: R.E.	With pinhole	Glasses: Yes No
L.E.	With pinhole	Glasses: Yes No
I. LIDS:	Cicatrix:	
	Ectropion:	
	Abnormality of cilla?	
II. CORNEA:	Pannus:	
	Scar:	
	Evidence of xerosis:	
III. CONJUNCTIVA:		
IV. LENS:	Opacities: <sup>1</sup> (Detail abnormalities - extent, position, arrangement and compositions.) <u>Accompany by sketch.</u>	
V. RETINA:	Macular abnormalities <sup>2</sup>	
	Other abnormalities <sup>3</sup>	

1. Any patient with lens opacity should be sent back for supplementary history regarding subjective loss of vision (onset and progression).
2. Look especially for pigmentary degenerative changes, holes in retina but give other findings in detail. (e.g. drusen etc.)
3. State any positive findings in discs, vessels, or periphery.

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Did you go to a hospital? Yes No  
Which? When?

Did you receive any blood examinations? Yes No  
Where? When?

Did you receive any treatment not already mentioned? Yes No  
What? Where? When?

Were you examined by any scientific group studying Radiation effect  
before ABCG? Yes No  
Where?  
When?  
By whom?  
What part?

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EYE EXAMINATION

Dept. No. \_\_\_\_\_

M-F No. \_\_\_\_\_

NOTES: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

IMPRESSION: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Date \_\_\_\_\_

\_\_\_\_\_  
Examiner

O P

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T R A N S L A T I O N

Certificate

NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

This is to certify that the above named was examined on

\_\_\_\_\_ in the ABCC Ophthalmology Clinic.

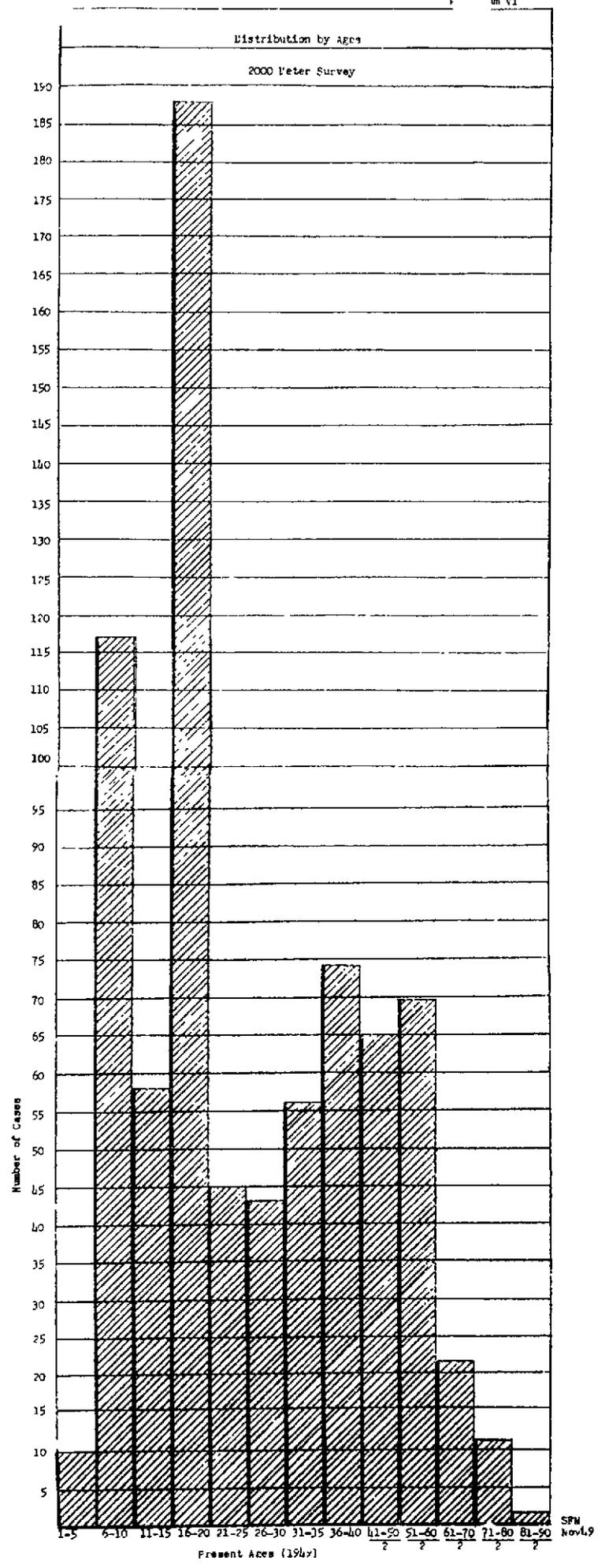
\_\_\_\_\_  
ABCC M.D.

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