A first study of the statistics of insanity and the inheritance of the insane diathesis / by David Heron.

UNIVERSITY OF LONDON
FRANCIS GALTON LABORATORY FOR NATIONAL EUGENICS

EUGENICS LABORATORY MEMOIRS. II.

A FIRST STUDY OF THE STATISTICS OF INSANITY AND THE INHERITANCE OF THE INSANE DIATHESIS

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THE FRANCIS GALTON EUGENIC LABORATORY.

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Some reconstruction of the Francis Galton Laboratory having taken place, it seemed desirable to provide the workers associated with it with a direct channel of publication of their own, in which their more extended memoirs should appear. It is hoped that the present series may be issued at short intervals. Subscribers should notify their intention of taking in the memoirs as they are published to Messrs Dulau & Co. Requests to exchange with similar publications, with archives and journals dealing with demographic and sociological problems, or with census reports should be directed to The Editor, Eugenics Laboratory, University College, Gower Street, London, W.C.

A First Study of the Statistics of Insanity and the Inheritance of the Insane Diathesis.

By David Heron, M.A., Galton Research Fellow in National Eugenics, University of London.

(1) *Introductory.* It will appear at first sight presumptuous that a layman should venture into a field which has been so much cultivated by the trained medical mind, and where such numerous pitfalls exist for those unacquainted with the various phases of mental disease popularly grouped under the broad term insanity. Even to the layman it may indeed seem imperative that each type of mental disease should be dealt with separately and the problem of inheritance considered for each apart. Undoubtedly this must form the last word on the subject, the final treatment of the "inheritance of insanity" when the data are available. But is the time ripe for any such investigation? May it not be that a broader treatment from the side of popular terminology may be in itself helpful as stimulating the minds of those in charge of the insane to see the question of heredity from another standpoint—that of the statistician? What appears from the statistical side at present so urgent is the need that those who have not only the opportunity but the clinical training necessary for accurate observation, should record their facts in a form in which the trained statistician can apply to them the methods of modern statistics. A careful examination of the Annual Reports of the Asylums of Great Britain and Ireland has led to the conviction that no data at present published would enable the statistician to reach any quantitative results as to the inheritance of any single form of brain disease. Even medical treatises as a rule go no further than stating the percentage of cases in which insanity or some other want of mental balance has been recorded in the family history. As long as we do not know the total number in each class of relatives of the insane person and the exact brain defect from which they have suffered; as long as we do not know the total number of relatives of a random sample of the sane population and the exact forms of neurosis or brain disease from which they too have suffered, any attempt at a full treatment of the "inheritance of insanity" is from the statistical standpoint

idle. What advantage can possibly arise from telling us that an insane person has so many alcoholic uncles if we do not know either the total number of his parents brothers and sisters, or the percentage of alcoholic members in the same grade of relationship of a sane individual of the same social class? But if an examination of the Annual Reports of the Asylums shows the statistician that little of real value for the problem of inheritance is as yet to be found in them, it does provide evidence that in many quarters the medical officers have themselves realised this fact. One sees evidence here and there that the need for slowly and steadily collecting complete family histories is being more and more recognised. This dull plodding work may not appear to have much fascination for those who long at once for brilliant generalisations and rapid conclusions; it is like the slow work of the astronomer who piles up data that his successor a century hence may by comparing the positions of stars at distant intervals learn the truth. But may we not apply to the medical investigator the words of Sir David Gill in his Presidential Address and urge that for him also the supreme duty is "to secure for future generations those data the value of which grows by time"?

These words are not written without some knowledge of the difficulties which attend the collection of complete family histories. It is admitted at once that the duties of many medical officers are far too multifarious to allow of work of this kind, of whatever national importance it may be; there are many of them whose tastes and abilities lead them in a different direction. It wants tact and even "slimness" to elicit the plainest facts, but the guile of the uneducated who form the bulk of the material is often of a very shallow kind, and it does not require much experience and knowledge on the part of the investigator to circumvent it*. It does, however, need the temperament that is not easily discouraged and is patient with much talking.

And again, even if the relatives are willing to give the fullest information in their power, what too often does it amount to? Why the statement that a grandparent, an aunt, or cousin was eccentric, alcoholic or "insane." They are too often wholly unable to specify the particular type of insanity, its cause or even duration. With the material at present available it would be almost idle to attempt any treatment of the inheritance of a special type of insanity. Sometimes the inquirer may have had the relative under his own charge, or may be able from the layman's account to make a shrewd guess at the type of illness, but in a very large number of cases we must be content with the broad statement that an Ancestor was "insane." The solution of this difficulty, and the present writer believes of many other difficulties in the statistics of

* It is not always, however, so transparent as in the following case narrated by a medical officer who takes very full family histories and sees (and compares the accounts of) all available relatives. In this case a father and mother had brought a son to the asylum. The father had been cross-examined and had stoutly maintained that there was no family history on either side. The medical officer in parting with him said he would like to see the mother, whom he had heard had also come to the asylum with the son would the man send her in? After some hesitation, he replied that he could not do so at present, for she was visiting a sister in the women's wards!

insanity is to establish a General Register of the Insane for preservation in the office of the Lunacy Commissioners. Each insane person would receive an index number, and this number would be preserved in case of transfer, relapse after recovery, or even permanent recovery. In this manner we should be able to estimate closely not only the total insane population, but also the number of the population who had at any time been insane, which is a very different matter, yet one of immense importance from the standpoint of heredity and of national eugenics. By inquiry of the keepers of this General Register of the Insane it would ultimately be possible for the medical officer of the future to complete in a great number of cases the particulars as to the ancestor, John Smith, stated by the relatives to have been "insane." It is thus that I would illustrate my reference to Sir David Gill's words. In special cases, especially in private practice, it may be possible in other ways to follow up the special type of insanity, but it must be remembered that the insane are not a very large proportion of the community, and for final conclusions the statistician will need very large numbers of each special type. We are justified in doubting whether such material can ever be accumulated except through the combined effort of many medical officers of the largest public asylums; yet it is precisely in such cases that the personal knowledge of the family is so often lacking. It can, we believe, only be supplied by that General Register of the Insane to which reference has just been made.

There are, however, two further points which suggest themselves to a layman approaching the subject from the statistical side. Some forms of insanity may be of singular distinctness and capable of differentiation from the mass of others with practical unanimity of the experts. But can we say that the experts will themselves agree to a general classification of types, or admit that some of these types may not be manifestations at different stages of the same original constitutional defect? It would seem that already there is more than a tendency among experts to revert to Dr Sankey's position "that insanity is but the process, and that the so-called varieties are merely differentiated by non-essential phenomena; that all insanities begin with melancholia, and tend to pass through a succession of stages in the order—melancholia, mania, and dementia, a succession liable at any time to interruption by recovery." In short, to take Dr Urquhart's position that "Insanity is a unity, not a fortuitous collection of kaleidoscopic systems each requiring a proper name*." It is not for a layman to express an opinion on this point, but while there is diversity of expert views, and while many hold the possible transition from one type to another, and treat insanity as a unity, the popular statement that John Smith had an "insane" ancestor may not be of such small scientific value as it appears at first sight. Initially this compulsory limitation of the method by which we may hope to reach conclusions may not result in such a heterogeneous and loose classification as some mental experts would suggest.

* See *Journal of Mental Science*, Vol. LIII. pp. 241 and 243.

The second point to which I would refer is one that touches closely on this first consideration. In the mass of family histories slowly accumulating in the Eugenics Laboratory, there appears to the observer a certain "correlation in heredity." Insane stock are liable to tuberculosis at a greater rate than sane stock; mentally defective offspring occur in families in which neuroses, alcoholism or insanity are more or less frequent. Physical or mental degeneracy of one type will be found in one member, and of a second type in a second member. There is, as it were, an inherited tendency to general degeneracy, which is something wider even than the vague "insanity," where many types are clubbed together under one name. This correlation in heredity manifests itself in other directions; the inherited tendency to digital defect may appear in one member as excess, in another as a true defect; and ophthalmic surgeons have drawn attention to the fact that abnormality of vision may take different forms in parent and offspring. It would appear as if the stock suffered from hereditary determinants which were unstable in character, and that the existence of such unstable determinants may be the mark of "degenerate" stock; the instability may be marked by more than one form of insanity, or states less emphasised than the insane, such as the neuroses which may be classed as want of mental balance. It may be long before material has been accumulated in sufficient mass to test quantitatively the forms of "cross-heredity" here referred to. We may hereafter find that even a wider category than the popular phrase "insanity" is the more truly scientific, that the inheritance of insanity is like the inheritance of pulmonary tuberculosis, the inheritance of a tendency, a condition or state, which under the suitable environment, the special mental or physical strain, the influenzal weakening or some kindred source, may become one form or another of accepted insanity. It is possible that this insane diathesis, the characteristic of the neurotic stirp is what we ought scientifically to treat as our heredity-unit. As a somatic measure of its existence and intensity the general term "insane" has been taken in this paper; just as in a similar investigation* the presence or absence of pulmonary tuberculosis—the result possibly of infection—has been taken as a measure of the intensity of the tubercular diathesis.

Even from this limited standpoint the question of the inheritance of insanity becomes of much interest; the very defects of the method showing how needful are further data and how many points are yet statistically without answer. When the classification of the types of insanity shall have proceeded further, when above all the family records shall have given us information as to these types in ascendant, descendant and collateral, then our insight will be deeper and we shall be able to test statistically the inheritance of each type and the correlation in heredity between types. In the opinion of the present writer this correlation should always be kept in view as a goal, even if a distant one, in dealing with family histories under the present difficulties. But while we strive for more definite data in greater quantities from

* Pearson, "A First Study of the Statistics of Pulmonary Tuberculosis," *Drapers' Research Memoirs* Dulau & Co.

the pathological side, is it not also worth pressing upon those who have medical science at heart, that no final treatment of the inheritance of any abnormal condition can be reached, until we have much more ample knowledge than we have at present of the family history of normal individuals? That is the *sine quâ non*, failing which no treatment of the inheritance of pathological conditions is valid. It is the endeavour to supply these data which leads in the present case to the difficulties and assumptions of our investigation.

(2) *Statistical Method.* In the preceding section we have discussed the justification such as it is of treating insanity as a unity, as a mark which denotes that certain members of a neurotic stock have in a more or less definite degree the conditions which lead to a mental breakdown of one or another type. We may express this by saying that they have a certain intensity of the insane diathesis. Now what we are concerned with is the inheritance of this insane diathesis, i.e. of those constitutional conditions, which under certain environments lead the individual to omissions or commissions on the basis of which he or she will find their way into an asylum, or be certified as insane. Theoretically we suppose that there exists a quantitative scale of this insane diathesis. In some individuals the extent or intensity of this constitutional condition is so low, that under no physical or mental strain would they be in the least likely to become insane. In others the intensity is so great, that they are unlikely under any circumstances to escape the slight pressure which will suffice to send the balance down on the wrong side. In others again an absolutely easy and physically well regulated life will preserve them, as similar conditions will preserve the well-to-do who come of tuberculous stock. But the possibility of such conditions lies only with the well-to-do, not with the struggling and often exceedingly ignorant mass of humanity which provides the bulk of the population of our public asylums. Even a long way above this level few lives can be spent without, especially at certain periods, considerable physical or mental strain. Is the intensity of the insane diathesis sufficient in such cases to lead to temporary or permanent confinement in an asylum? Theoretically we want a mark on the scale of the insane diathesis, and then we shall say that under the normal environment of the present age, all who fall below this escape the asylum, all who exceed it will sooner or later be certified. Now it is quite clear that this is practically unattainable; A and B may be sensibly in equal possession of the insane diathesis, but A's environment or habit of life may preserve his sanity and B's destroy his. But the question is not whether any theoretical mark can be exact, but whether it can be drawn sufficiently close to the actual state of affairs to be useful in describing that state in the mass. We believe that the classification into sane and insane is probably as close as any made in vital statistics. There are undoubtedly a considerable number of neurotics, eccentrics and "cranks," who under a modified environment would need to be classed as insane. The time may actually come when we shall be able to recognise

other marks on the scale of insane diathesis beside the division which under the normal environment of modern life leads to a certificated insanity. A lower mark might for many social and family purposes be of value. Our only mark at present is not a true line, it is rather of the nature of a region or blur upon the scale, but if the scale be sufficiently long relatively to this region, this does not necessarily invalidate its usefulness.

Premising such a practical division if we take N pairs of individuals and form a fourfold table thus:

TABLE I.

First Individual.

Second Individual.	Sane	Insane	Totals	
Sane ...	a	b	$a+b=p_2N$	$p_1+q_1=1$
Insane ...	c	d	$c+d=q_2N$	$p_2+q_2=1$
Totals	$a+c=p_1N$	$b+d=q_1N$	$a+b+c+d=N$	

by classifying the member of each pair under the heading of sane or insane, we shall be able to judge of the relationship in the matter of sanity. In this case $b+d$ will represent the number of insane individuals in the community of the type of the first individual, $a+c$ the corresponding number of sane ones. Now it is quite conceivable that some few individuals who fall into the $a+c$ group have a greater intensity of the insane diathesis than some of those actually included in the certified insane $b+d$. But it is contended that although the division between $a+c$ and $b+d$ is a blur, and individuals near that region may be classified according to circumstances in one or other category, this is not so large a proportion* as to invalidate conclusions drawn from a table of this kind. Let us speak of the first individual as belonging to Class A, and of the second individual as belonging to Class B. Then if the link between Classes A and B had no influence at all on the intensity of the insane diathesis, the chance of the first individual being sane would be p_1, and of the second individual being sane would be p_2, and in a population of N pairs the number of pairs of sane individuals to be expected would be Np_1p_2. Similarly the number of cases in which both individuals were insane would be Nq_1q_2. Again, the chance of the first individual being insane and the second sane would be Nq_1p_2, and the first sane and the second insane would be Np_1q_2. Thus our fourfold table, if the intensity of the insane diathesis in the Classes A and B is independent is:

* The law courts allow us to estimate something of the extent of the blur in one social class, and so to form conclusions as to the proportion in all classes. I am not dealing here with the large number admitted by their relations to be insane, but who in the same social class are not for family reasons certified.

TABLE II.

First Individual.

Second Individual.	Sane	Insane	Totals
Sane ...	Np_1p_2	Nq_1p_2	Np_2
Insane ...	Np_1q_2	Nq_1q_2	Nq_2
Totals	Np_1	Nq_1	N

It will be noted that in this table all the totals are the same as in the previous case, but the numbers in each of the four classes are not necessarily the same.

Now $$a - Np_1p_2 = a - (a+c)\,(a+b)/N = \frac{ad-bc}{N^2}N,$$

$$d - Nq_1q_2 = d - (b+d)\,(c+d)/N = \frac{ad-bc}{N^2}N.$$

Similarly, $Nq_1p_2 - b = \frac{ad-bc}{N^2}N$, and $Np_1q_2 - c = \frac{ad-bc}{N^2}N$.

Thus we can pass from the second table with independent degrees of the insane diathesis in the Classes A and B to that of the first class with some dependence of the insane diathesis, by transferring the fraction $\eta = \frac{ad-bc}{N^2}$ of the total population from both of the mixed groups (sane–insane) to either of the like groups. Or, when there is relationship between the intensities we emphasise the like groups by a proportion η of the total population. It will be at once clear that $\eta = 0$ is the sufficient condition for independence of the two groups. For example, if $\eta = 0$, when the first group consists of parents and the second of offspring, there cannot be inheritance of the insane diathesis from parent to offspring. It does not follow that if η differ from zero, that there is of necessity true inheritance, the relationship might be due to a common environment of each pair differentiated from the environment of other pairs. But if we find, working fairly in one class with a moderate normal intensity of environment, that η is very considerable, it is highly probable that the relationship is due in great part to inheritance. Indeed much that is often put down to environment—commendable or objectional personal habits, control or want of control of economic environment—results from inheritance itself, and may be only another phase indeed of the inheritance of that neurotic constitution which is part of the insane diathesis.

It is clear that η is a numerical quantity, and all our inquiry ultimately turns on what is the relative magnitude of η. But it is convenient to measure intensity of relationship by a quantity which shall lie between -1 and $+1$,

being 0 when the quantities are independent, +1 when one is absolutely determined positively, and −1 when one is absolutely determined negatively by the second. Now such a quantity is termed a coefficient of correlation, it is a measure of the intensity of resemblance between two individuals of related classes. Clearly there may be more than one function of η which satisfies such conditions, it may also be a function of p_1 and p_2 since these depend only on the individual classes and not on their relationship. Thus we may write for our correlation constant

$$r = \text{function of } \eta_1,\ p_1 \text{ and } p_2.$$

The problem arises: what is the nature of the function we shall choose? Now it would be valuable to choose one the intensity of which shall be independent of the position of the mark on the supposed scale, which measures the intensity of the insane diathesis. For example, suppose we were capable of drawing it at a slight tendency to melancholia, then if we could choose a function which would give r the same value as when we draw the mark at certified insanity, it would be of great value. No attempt of this kind can however be made unless we have some knowledge of the distribution of the various intensities of the insane diathesis in the community—a so-called frequency distribution. We have at present no such knowledge, and accordingly in selecting r as a function of η we must be led by some hypothesis. This hypothesis is that within wide limits the distribution of frequency in physical, psychical and pathological characters in man approaches a certain type termed the Gaussian or normal type. We know that this is true for many measurable physical characters; there is considerable evidence that it is at least approximately true for a number of psychical characters. Recent work suggests that even in the matter of severity of attack in disease the maximum frequency is not with the mildest cases, but that the frequency rises from the mildest cases, reaches a maximum, and then falls to the severest cases. It may easily do this and still be far from possessing the full characters of the Gaussian distribution; but still as a first approximation and until we are in a position to determine the true frequencies of each intensity, the Gaussian scale may be used with partial justification and often with much suggestiveness. Whatever be the scale the sensible deviation of η or r from zero shows quite definitely that the character in the two classes is correlated, but the legitimacy of comparing the intensity of the correlation in this case with that of others undoubtedly depends for its weight on the degree of confidence we have in the basal character, in this case the intensity of the insane diathesis, following the normal distribution with at least a moderate approximation.

(3) *Values of Necessary Statistical Constants.* For the purposes of diagnosis as well as for eugenic inquiry, it is not sufficient to know what members of a stock are at the time of the investigation certified as insane. If the insane diathesis be

inherited, it is much more important to know the number of relatives who have at any time been certified as insane. In the present memoir we understand by the insane members of a family those who at any time in their lives have been treated as insane. Again, if we take actual asylum statistics and the family histories collected by their medical officers, we shall find in nearly all cases that the record is incomplete, that is to say, that there are members of the stock whose history with regard to possible insanity is not yet completed. These two considerations (a) the distinction that must be made between persons at present insane, and who have at some time in their life been insane, and (b) the incompleteness of the family histories, form the chief difficulties of and accurate investigation of the problem of insanity.

Let us return for a moment to Table I. To ascertain whether insanity is inherited or not, we need to take N individuals, who form a random sample of the community, or perhaps of some fairly homogeneous class of it. But the smallness of the class $b+d$ as compared with $a+c$ means that a very large sample N indeed has to be taken to get conclusive results. It is almost impossible to approach the inheritance of pathological conditions from the standpoint of a general sample of the population, unless a wide scheme of collecting family histories could be organised and carried out by combined action of the medical profession. We are reduced to approaching the problem indirectly. If we collect family histories within the asylums, we shall know subject to (i) the errors of the record, and (ii) the incompleteness of the record, the number of sane and insane relatives of the insane individual; we shall accordingly have the quantities b, d and c for a random sample of unknown size for any pair of related individuals. But we shall not know how many pairs of individuals both sane correspond to this sample—i.e. what is the magnitude of a. If we knew the ratio, however, of the number of sane to insane individuals in a random sample N of the community, we might from the ratio of $a+b$ to $c+d$ deduce the size of the fourth category a and so complete our random sample. To determine this ratio is the first problem; the second problem is the allowance for the incompleted family history.

When we remember that insanity is frequently temporary or intermittent, it will be obvious that for the purposes of inheritance we have no more justification for omitting a member of a family who has ever been in an asylum, than for excluding a person who for the present is in an asylum. Our goal must be to ascertain whether during the whole of life there has been evidence of that intensity of the insane diathesis which leads to certifying. Even here we are met by the disturbing factor that the neurotic condition may itself lead to shortness of life, and so to the reduction of the apparent amount of insanity in any insane stock. This factor, however, is one which we see no means of allowing for at present.

Accordingly for our present purposes the extent of insanity in the community cannot be measured by the percentage of the population at any time in the asylums of the country (assuming for the moment that all the certifiable in the social class dealt with are certified). What we desire to know is the number of living persons,

who at present, or at any time during their lives, have been insane. If there are m persons in an asylum at the present moment, and μm living who have been in that asylum but are now not in other asylums but following the ordinary life of the sane, what is the value of μ? Only by a knowledge of μ can we reach a measure of what for eugenic purposes is the force of insanity in the country; only by such means can we determine α even approximately. On first approaching this subject it appeared that it would be easy to find statistics bearing on this point, but it soon exhibited itself as a very intricate and difficult problem. Asylums could provide a record of patients dismissed as recovered, but the after fate of these recoveries was not easy to follow. It was not certain how far (i) they were identical with relapses in the same asylum, (ii) they were inmates of other asylums, or (iii) dead.

The impressions, not definite statistical data, of a number of medical officers on this point have been collected; they varied somewhat largely; perhaps, the most reliable estimate, the one that showed most careful thought for the various difficulties to be encountered was that $\mu =$ about 2, or the insane of the asylums must be multiplied by about three to deduce the force of insanity in the community. It is obvious that our proposed General Register of the Insane would at least provide us with the number of those at any time confined in an asylum and now no longer confined; it would also tell us much of the history of the once insane. But it would still fail to tell us of those who died after recovery and before the asylum census was taken. With the known age of dismissal, however, we approach a problem not impossible to the vital statistician or the actuary, if he were once in possession of a reliable system of death rates. Now these death rates at each age are known for the normal population; they are also known for the insane asylum population; but we do not know them at present for the "recovered" population. It is extremely unlikely that they are the same as for the normal population.

We know that between 15 and 25 the mortality of the insane is no less than 20 times that of the sane; between 25 and 45, about 11 times that of the sane; between 45 and 65, about 4·5 times; and over 65, about 2·5 times that of the sane*. In the total lunatic population for equal numbers of both sexes at the same ages, it is about 7 times as great as in the general population. Accordingly it is extremely unlikely that the death-rate of the "recovered" will be that of the general population; it will probably at each age lie between that of the latter and that of the insane.

At this stage Dr John Macpherson of the Scottish Lunacy Commission came to our aid and kindly furnished the Laboratory with a progressive history of 1319 insane patients who were admitted for the first time to Scottish Asylums in 1868. The history of this group is traced until 1897. From these figures an endeavour has been made to determine approximately the number of persons in the sane population who have at any time been in an asylum. The problem is far from being an easy one. The data were the number dying in the asylums each year, the number discharged

* *Report of Commissioners in Lunacy*, Mortality of Insane for 1904.

and the number readmitted out of the original 1319. Of those dying outside the asylums, there was of course no record. There was no hope of very great exactitude in the solution, for the age data were not available, but even so the problem was not actuarially an easy one. It was kindly undertaken for the Eugenics Laboratory by "Student" at that time working in the Biometric Laboratory, and the results of his analysis are given below*. We may obtain a lower limit to those who have ever been in an asylum by assuming that the death-rate among those who have recovered is the same as among those who are actually insane. This assumption gives a living population of recovered insane approximately equal to the number of asylum insane.

The second assumption made was that for the first six years after recovery the death-rate was half that of the insane, or about 35 per 1000 and afterwards fell to 30 per 1000, remaining constant at that figure until all were dead about 60 years after first admission. This assumption gives a population of recovered insane of about 1·5 times the asylum population.

The third assumption made was that the death-rate remained constant at about 20 per 1000 during the first 20 years after recovery, subsequently rising uniformly until all were dead at 70 years after admission. On this assumption the recovered insane population is about three times that of the actually insane.

This gives, perhaps, an upper limit to the number of living and recovered insane, the estimate of our best judge was *twice* the asylum population. According to the three assumptions we must multiply the insane population by 2, 2·5 and 4 respectively to obtain the force of insanity in the population.

Our material, to be discussed in the next section, being drawn from a Scottish source, we have next to enquire what is the extent of actual insanity in Scotland. According to the Scottish Census Report of 1901, there were in that year 13,668 individuals returned as "lunatics," of whom 13,457 were returned as over 20 years of age. The total population of Scotland numbered 4,472,103, of whom only 2,520,866 were over 20 years. It is clear that if we base the ratio of the sane to the insane upon the total population we shall have a very different result to that arising from limiting our population and cases to over 20. We cannot take into account the infant population because in our family histories starting from the offspring, one of whom is already in an asylum, we practically exclude infancy and deal only with the adult population. From the above figures we find that out of 1000 individuals over 20 years 5·32 are insane.

If instead of taking the census returns, we take the figures given in the Scottish Lunacy Commissioners' Report for 1901, we find that there were on the 1st of January, 1901, 15,475 lunatics of all ages. The age distribution is not given in this case, but if we assume that it is approximately the same as in the Census Report, then out of 1000 adult individuals 6·04 are insane. Accordingly between ·5 and ·6 per cent.

* A full discussion of it is not entered into here, because we hope shortly to be provided with more complete data and to enter then on a full treatment of this most important point.

adult individuals in Scotland are actually insane, and on the basis of our three estimates we must say that 10 to 12, 12·5 to 15, 20 to 24 per 1000 of the adult population respectively are or have been at some time insane. Our tables have been worked out on the three assumptions, namely, we suppose that 1, 1·5 and 2 per cent. of adults are from the inheritance standpoint to be considered insane. Values for a 2·5 per cent. base have also been extrapolated; these would correspond to the Lunacy Commissioners' returns with a death-rate for the "recovered," only slightly above that of the general population.

A further investigation was made and a considerable time spent upon it with a view to determining whether the social class from which the patients in our data were drawn provided a greater or less than normal quota to the total insane population. This was a point which might to some extent modify our results. It is a point also of very vital interest to the community at large. The data as to calling and position in our material were fairly ample; but the census classifications on which we had to work were so hopelessly vague that ultimately we had to give up the problem in despair. The class distribution of lunacy cannot be determined until the census categories are selected with somewhat greater reference to the needs of the sociological investigator.

The manner in which we can deal with the incompleteness of the family history will be discussed later under the separate tables.

(4) *Material.* The material on which the present memoir is based was most kindly provided by Dr A. R. Urquhart, physician superintendent of the James Murray's Royal Asylum, Perth. In this asylum the patients are all paying patients*, and may fairly be said from the occupations of the record to belong to the middle and lower middle classes. Hence it would have been desirable to determine the special lunacy rate for these classes, but for the reason given above we can only take the general lunacy rate of the country†. Dr Urquhart has been at the head of this asylum for nearly thirty years, and has remained in touch with patients who have been discharged to a much greater extent than is frequently the case. The records which have been compiled by Dr Urquhart personally are therefore of great value on account of their completeness, uniformity and the long period over which they extend. If the statistician wish for a greater mass of material, he knows only too well that this can only be forthcoming when more medical officers are willing to provide data like those of Dr Urquhart.

The Perth records consist of 331 family trees. Each gives the total number of brothers and sisters of the patient, stating the order of birth and in many cases the

* The ordinary minimum board-rate is £84 per annum, but a few patients are admitted at reduced rates.

† Pearson's Family Records seem to indicate a higher rate than the Scottish 1 to 2 per cent. for middle class families, but 300 families are not sufficient to justify any final conclusions.

age of each, and classifying each as insane, neurotic, alcoholic, epileptic, eccentric or normal. Similar facts are in every case given about the parents of the patient, while in some cases the record is extended to the grandparents and to the children of the patient. The total number of the parents' brothers and sisters is, however, not invariably given. In the case of insane individuals the age at first attack is nearly always given. Occasionally, although the total number in the sibship of the patient is given, the order of birth has not been ascertained, or the age at first attack is wanting. It thus happens that the total number of cases used in the different investigations of this memoir will not be invariably the same. The material itself forms the basis of the statistical part of Dr Urquhart's recent most interesting Morison Lectures*; the present writer in that case supplied the table dealing with the differential incidence in the family, a point further discussed below, and this memoir appeals at points to data already tabulated by Dr Urquhart.

(5) *Preliminary Statistical Investigation.* It is needful before starting on the direct investigations as to inheritance to form a fairly definite idea of the mean age of incidence of the first attack. Table III gives Dr Urquhart's data for a series of 400 males and 382 females, and the calculated means and standard deviations are placed below.

TABLE III. *Age of First Attack.*

Age	Under 20	20—24	25—29	30—34	35—39	40—44	45—49	50—54	55—59	60—64	65—69	70—74	75 and upwards	Totals
Males	45	52	66	55	38	34	29	28	13	17	15	7	1	400
Females ...	21	55	68	53	35	38	26	36	13	11	10	9	7	382

	Males	Females
Mean Age of Onset =	36·2 ± ·5,	36·5 ± ·5 years.
Standard Deviation =	14·7 ± ·4,	14·7 ± ·4 years.

It will be noted at once that these data would indicate an equal age at incidence of insanity in both sexes and an equal variability at that age. But although the material is far from ample enough to warrant any attempt at present at further analysis, it does not seem that insanity differs from cancer or pulmonary tuberculosis in giving an equal average age of first attack for both sexes. The trained eye of the statistician will mark at once that not only are both distributions very skew, but they differ in the two sexes, youthful insanity being more prevalent in the male, senile insanity in the female; the apparent equality of mean ages being due to actual differences of the distribution in middle and late middle life. In fact there is

* On Insanity with special Reference to Heredity and Prognosis. *The Journal of Medical Science*, Vol. LIII. p. 233 *et seq.*, April 1907.

little doubt of the heterogeneity of the age frequency distributions; they must be when the material is ample enough divided up into their components in the manner in which the general mortality curve has been treated by Pearson*, and the general sickness curve by Elderton†. There is an insanity of youth with its modal age between 25 and 29, one of early middle life centering about 40, one of change of life, centering 50—54, and these are apart from senile insanity occurring at a later stage. The relation of these components to the corresponding mortality and sickness factors would form an extremely interesting study, but the investigation must, if it is to be profitable, be postponed until the data can be reckoned by thousands not hundreds of cases for each sex.

A sample taken out of Dr Urquhart's records of 219 cases gave a mean age of $37{\cdot}9 \pm {\cdot}6$ and a standard deviation of $13{\cdot}6 \pm {\cdot}4$, thus confirming the general result reached above.

Now the chief bearing of this result on our present investigation is of the following kind: the average age at first attack being 36, the average age of the parents must be nearly sixty, or the parents will have reached an age at which 90 per cent. of persons, who are ever insane will have had their first attack. But there is a still more cogent point, there is an inheritance not only of the diathesis, but in most cases of disease an inheritance of the approximate age of incidence. Thus if the offspring were to show insanity of youth at 25, the parent who will then be nearly 50, would have passed the danger zone at least for that class of insanity; while if the offspring shows insanity at change of life, the parent will have passed the period practically of senile insanity. Accordingly in the great bulk of cases, if we start from the insane patient, we may be fairly sure that the parental history is practically completed. In other words given a random sample of asylum patients we know fairly accurately (supposing the record not in error) how many are born of sane, how many of insane parents. On the other hand, when we turn to the enquiry as to the offspring of insane parents, we are on less certain ground, because the record of the younger generation may be far less complete. What we actually find is this, that of 198 sons born of insane parents 49 were recorded as insane, and of 210 insane daughters 52 were recorded as insane. In other words 25 per cent. of the offspring of insane persons at one time or another in their lives exhibited insanity. Now Pearson has found that even in the incomplete records of families with pulmonary tuberculosis, 30 per cent. of the offspring of a tuberculous parent exhibit tuberculosis, and that when the family history is completed he considers it probable that nearer 50 per cent. of the offspring will be recorded as tuberculous. The difficulty then arises as to whether our category of the insane offspring of insane parents is sufficiently largely represented. The point can only be settled when a full supply of wholly completed family histories is available. But the following points should be noted: (i) Dr Urquhart's data have been accumulating for 30 years and in many cases the record is

* *Phil. Trans.* Vol. 186 A. pp. 406—411. † *Biometrika*, Vol. II. pp. 260—272.

actually complete, the members of the same stock coming to the same asylum; (ii) Pearson's Family Records, indicate an even higher percentage (see Appendix). (iii) the argument from tuberculosis is not valid; the present insanity data are more complete than the tuberculosis data, because the mean age of first attack is higher and because the families have been under observation during a longer period; yet the unmodified record gives a sensibly lower percentage of offspring attacked than in the case of tuberculosis, namely 25 per cent. as against 30 per cent. There is no reason why the incidence should be the same in the two cases unless we start with some definite theory as to inheritance, e.g. the Mendelian. In Table IV below there is, however, little to warrant the application of that doctrine to the present data.

TABLE IV.

Nature of Parents as to Insanity	Total Offspring		Percentage Offspring	
	Insane	Sane	Insane	Sane
Both Sane ...	314	1179	21	79
One Insane ...	93	299	24	76
Both Insane ...	4	4	50	50

Now these results are, remembering the probable error of the last result, singularly close to those found by Pearson for pulmonary tuberculosis*. They compel us to consider sanity as dominant, which involves the following scheme:

TABLE V.

Matings	Expected to have Diathesis	Recorded to have Diathesis	
		Tuberculosis	Insanity
$(RR) \times (RR)$	100 per cent.	57 per cent.	50 per cent.
$(RR) \times (DR)$	50 per cent.	29 per cent.	24 per cent.
$(DR) \times (DR)$	25 per cent.	21 per cent.	21 per cent.

No argument in favour of Mendelism seems possible on these figures†. Here, as in the case of tuberculosis, there is no obvious reason why the expectation should be so much more closely fulfilled by the record in the third mating than in either of the other two. No great stress is really to be laid, however, on the apparently close agreement of the two diseases, because the record for insanity is probably much more complete. The question of how far other members of the patient's sibship would be

* "A First Study of the Statistics of Pulmonary Tuberculosis," *Drapers' Research Memoirs*, Dulau & Co., 1907.

† Exactly as in the tuberculosis data, the percentages required to complete the Mendelian proportions are wholly different in the three cases, whereas we should expect them to be the same.

classified as insane if the record were completed up to death was investigated in another manner. If we take as our "subject" the oldest member in the sibship of the insane, then we should anticipate that the greater his age at the time of the record, the larger would be the recorded number of insane in the sibship. The actual number of insane lies between 1 and 4 to the sibship, and the correlation between age of the oldest member and the number of insane was found to be $\cdot 14 \pm \cdot 04$. I think we are justified therefore in concluding that, owing to the incompleteness of the record, a small but definite correlation exists between number of insane and age of oldest member of sibship. But the magnitude of the correlation is not such as to sensibly affect our results. Such effect as it would exercise must tend however to increase the measure of inheritance.

We have accordingly made no attempt in the present case to correct the number of insane offspring of insane parents as found from the sibships of the insane, merely noting that it is probably too low. The *desideratum* is a selected series of completed family histories, or what is the same thing, of ancestral histories carried back fully to the grand-parental generation. When these are forthcoming in sufficient number we may endeavour to apply further corrections to our results.

(6) *Parental Inheritance.* Counting each insane patient twice, once for each parent, we find that the 410 male patients had 49 insane and 361 sane parents. The insane parents were further credited with 149 sane offspring. Dealing with female patients, we find that 52 had insane parents and 360 sane parents, and that these 52 insane parents were credited with 158 sane offspring. Thus Tables VI and VII give the data worked out for male and female pedigrees respectively. In these both father and mother are included as separate parents; and both sons and daughters are included in the offspring. The distinction between the two tables lies in the fact that in the first case we proceed from the record of 205 male patients, and in the second case from 206 female patients. The object of the double treatment is merely to divide the material into two groups for purposes of confirmation. The amount of material was not sufficient to justify us in breaking it up into the four sub-groups which would be needful had we dealt with inheritance from mother and father to son and daughter.

TABLE VI. *Male Pedigrees.*

Offspring.	Parents. Insane	Not Insane	Totals
Insane ...	49	361	410
Not Insane	149	x	$149 + x$
Totals	198	$361 + x$	$559 + x$

TABLE VII. *Female Pedigrees.*

Offspring.	Parents. Insane	Not Insane	Totals
Insane ...	52	360	412
Not Insane	158	x	$158 + x$
Totals	210	$360 + x$	$570 + x$

The next stage in the investigation is to find x the number of pairs of sane parents and offspring which would correspond to these results as a random sample of the general population. This is done by treating the patients, i.e. the offspring, as forming the basis of the random sample. The parents whether insane or sane are not a random sample, for they are selected by the very fact that they have become parents. Thus if our results can be relied on, the proportion of the insane among the members of the general population who are parents ought only to be about half as large as the proportion of the insane among the general population as a whole. This seems a not unreasonable conclusion.

Tables VIII, IX, X, XI, XII and XIII, give Tables VI and VII reduced to random samples of the general population on the basis of 1, 1·5 and 2 per cent. of that population having at one or other period in their lives been insane*.

Complete Tables, Random Samples of General Population. 1°/₀ Basis.

Table VIII. *Male Pedigrees.*

Parents.

Offspring.	Insane	Not Insane	Totals
Insane ...	49	361	410
Not Insane	149	40441	40590
Totals	198	40802	41000

Table IX. *Female Pedigrees.*

Parents.

Offspring.	Insane	Not Insane	Totals
Insane ...	52	360	412
Not Insane	158	40630	40788
Totals	210	40990	41200

Complete Tables, Random Samples of General Population. 1·5°/₀ Basis.

Table X. *Male Pedigrees.*

Parents.

Offspring.	Insane	Not Insane	Totals
Insane ...	49	361	410
Not Insane	149	26774	26923
Totals	198	27135	27333

Table XI. *Female Pedigrees.*

Parents.

Offspring.	Insane	Not Insane	Totals
Insane ...	52	360	412
Not Insane	158	26897	27055
Totals	210	27257	27467

* The process is perfectly simple, e.g. taking the 1·5 per cent. basis, then in Table VI we must have 410 equal to 1·5 per cent. of $559+x$, or $410/(559+x) = 1{\cdot}5/100$. Hence $x = 26774$.

COMPLETE TABLES, RANDOM SAMPLES OF GENERAL POPULATION. 2°/₀ BASIS.

TABLE XII. *Male Pedigrees.*

Offspring.	Parents. Insane	Parents. Not Insane	Totals
Insane ...	49	361	410
Not Insane	149	19941	20090
Totals	198	20302	20500

TABLE XIII. *Female Pedigrees.*

Offspring.	Parents. Insane	Parents. Not Insane	Totals
Insane ...	52	360	412
Not Insane	158	20030	20188
Totals	210	20390	20600

These six tables were then dealt with by the processes briefly indicated in § (2). In every case η was not only significant, but very markedly significant. There can thus be not the slightest doubt about the inheritance in a marked manner of the insane diathesis, the test for its presence being taken as sojourn in an asylum during some period of life. The equations determining r for each table are given below, and the results, together with those for a 2·5 per cent. basis deduced by extrapolation are given in Table XIV.

From Table VIII :

$$3{\cdot}069,329 = r + 3{\cdot}010,076r^2 + 4{\cdot}188,927r^3 + 2{\cdot}236,540r^4 - {\cdot}011,683r^5 + {\cdot}585,298r^6 + {\cdot}892,381r^7 - {\cdot}043,283r^8, \qquad r = {\cdot}61.$$

From Table IX :

$$3{\cdot}089,375 = r + 2{\cdot}988,390r^2 + 4{\cdot}118,229r^3 + 2{\cdot}162,678r^4 - {\cdot}010,614r^5 + {\cdot}606,953r^6 + {\cdot}870,504r^7 - {\cdot}038,999r^8, \qquad r = {\cdot}62.$$

From Table X :

$$2{\cdot}214,009 = r + 2{\cdot}652,858r^2 + 3{\cdot}077,276r^3 + 1{\cdot}125,\ 91r^4 - {\cdot}073,535r^5 + {\cdot}660,835r^6 + {\cdot}424,804r^7 - {\cdot}052,418r^8 + {\cdot}383,431r^9, \qquad r = {\cdot}58.$$

From Table XI :

$$2{\cdot}229,678 = r + 2{\cdot}631,684r^2 + 3{\cdot}018,521r^3 + 1{\cdot}070,584r^4 - {\cdot}059,248r^5 + {\cdot}668,376r^6 + {\cdot}408,629r^7 - {\cdot}038,513r^8 + {\cdot}388,975r^9, \qquad r = {\cdot}58.$$

From Table XII :

$$1{\cdot}755,039 = r + 2{\cdot}402,228r^2 + 2{\cdot}398,719r^3 + {\cdot}602,828r^4 - {\cdot}042,817r^5 + 612,475r^6 + {\cdot}182,548r^7 - {\cdot}002,088r^8, \qquad r = {\cdot}55.$$

From Table XIII :

$$1{\cdot}769,983 = r + 2{\cdot}381,450r^2 + 2{\cdot}014,833r^3 + {\cdot}574,832r^4 - {\cdot}012,929r^5 + {\cdot}612,159r^6 + {\cdot}173,175r^7 - {\cdot}035,394r^8, \qquad r = {\cdot}56.$$

The close agreement not only between the final results in each case for the male and female pedigrees, but in the coefficients of the equations themselves is noteworthy and justifies our extrapolation for the case of 2·5 per cent.

TABLE XIV. *Ancestral Heredity, assuming various Percentages of Insane.*

	On 1°/₀ Basis	On 1·5°/₀ Basis	On 2°/₀ Basis	On 2·5°/₀ Basis
Male Pedigrees . .	·61	·58	·55	·52
Female Pedigrees ...	·62	·58	·56	·53

The values obtained are undoubtedly rather high, even on the 2·5 °/₀ basis. It is possible that the prevalence of the insane diathesis in the community at large has been somewhat underestimated, proceeding as we do from the asylum evidence of its existence. Pearson, proceeding on the wider basis of "want of mental balance" and including the eccentric, neurotic and alcoholic, obtained a distinctly lower value*. But comparing the above results as they stand with those reached by other investigators for pathological conditions, for physical measurements and mental characters, summarised in Table XV, we must conclude that:

The insane diathesis is inherited with at least as great an intensity as any physical or mental character in man. It forms, considering the difficulties and assumptions of the investigation, probably no exception to an orderly system of inheritance in man, whereby *on an average* about one half of the mean parental character, whether physical, mental or pathological, will be found in the child. It is accordingly highly probable that it is in the same manner as other physical characters capable of selection or elimination by unwise or prudential mating in the course of two to three generations.

If it be said that the inheritance of insanity has been long a well recognised clinical experience, we can only reply: Let it be admitted. At the same time it is needful to point out that the whole of the medical data hitherto published on the subject seem lacking in the precision needful to give a logical proof. Not only will one, two and even sometimes three of the numerical values necessary for the fourfold table which demonstrates the existence of the association be found lacking, but the consciousness that they are lacking be also absent. A point so fundamental for the whole appreciation of heredity as the number of the insane, recovered and alive, has not so far as we are aware been hitherto taken into account. Heredity is over and over again recorded as a principal or contributory cause of insanity, although the average number of the insane in the stock of the sane individual has not been discussed. With equal logic the insanity of one member of a family might be

* *British Medical Journal*, May 27, 1905.

considered as the principal or contributory cause of the sanity of the sane members. It is the old story, which needs endless reiteration. From statistics of the pathological section of the population alone no argument as to inheritance can be deduced. Only by actual data as to the normal section can the evidence of the pathologist be made complete. It is necessary to supplement the data which the asylum or sanatorium provides, either directly by large random samples of the general population, or indirectly by census or other vital statistics.

TABLE XV. *Intensity of Parental Inheritance.*

Condition	Source of Data	Computer and Locus	Minimum Value	Maximum Value	Probable Value
Pathological:					
Pulmonary Tuberculosis ...	Dr River's, Crossley Sanatorium	Pearson, *Studies in National Deterioration*, II.	·40	·60	·50
Deaf Mutism ...	Dr Fay's Data ...	Schuster, *Biometrika*, Vol. IV., p. 466 et seq.	·45	·62	·54
Insanity ...	Dr Urquhart's Data	Heron, Present Memoir ...	·52	·62	·57
Physical:					
Stature	Pearson, Family Measurements	Pearson and Lee, *Biometrika*, Vol. II., p. 378	·49	·51	·50
Span			·45	·46	·46
Forearm ...			·41	·42	·42
Eye-Colour ...	Galton, Family Records	Pearson and Lee, *Phil. Trans.*, A 195, p. 106 et seq.	·44	·55	·50
Psychical:					
Intelligence ...	Pearson, Family Schedules	E. M. Elderton, Pearson, *Scope of Eugenics*, pp. 31—3	—	—	·58
,, ...	Oxford, Class Lists ...	Schuster and Elderton, *The Inheritance of Ability*, p. 41	·44	·54	·49

(7) *Fraternal Inheritance.* Our data enable us to test how far the above appreciation of the intensity of the inheritance of the insane diathesis is confirmed by the resemblance in this character of siblings, i.e. brothers and sisters. When the material available is far larger than at present, it will certainly be desirable to separate the sexes. But as we have only 315 families, and the mean age of first attack is very much the same for both sexes, they have in this memoir been dealt with together.

Now out of the 315 families with one sibling insane, there were 404 insane individuals and 1433 sane individuals, when we have excluded children who "died in infancy" or who are under 20 years of age and have not yet entered the "danger zone." It will be clear that even with these limitations the family record is not complete. We should probably not err, if we supposed that on an average at least $\frac{1}{3}$ of a sibship affected with insanity in one of its members will be found insane on completion of the record. But a correction for the incompleteness of the family record, though far more necessary here than in the case of parental inheritance, has not been made, as it would lead us into too hypothetical a field. We content our-

selves by remarking that the fraternal correlation will probably come out too low, i.e. will have a minimum value on this account. Forming each pair of siblings out of our 315 families*, or $n\,(n-1)$ siblings for a family on n, we obtain Table XVI, as representing the uncorrected table, for tainted stocks only, in a symmetrical form.

TABLE XVI. *Incomplete Table for Fraternal Heredity. Tainted Stocks only.*

Second Sibling.	First Sibling. Insane	Not Insane	Totals
Insane ...	250	1681	1931
Not Insane	1681	$6490+x$	$8171+x$
Totals	1931	$8171+x$	$10102+x$

Now assuming Table XVI to represent—what it does not do accurately—the full extent of insanity in tainted sibships, we have to add the pairs of siblings x due to untainted stocks in a random sample of this size. This is done as follows. Suppose y per cent. of the community are insane, then $404\times\left(\frac{100}{y}-1\right)$ would be the corresponding number of sane members. Of these 1433 are already included in our table as arising from the tainted stock. Hence corresponding to 404 insane we have $z=404\times\left(\frac{100}{y}-1\right)-1433$ individuals arising from sane sibships. Next, if we can assume that the fertility of the tainted stocks be not sensibly less than that of the sane stocks—which will be justified later—we have a rule of three sum to find the number of pairs of siblings which would arise from the above z individuals, for 1837 individuals gave rise to 10,102 pairs. Thus finally:

$$x=\frac{10102}{1837}\left(\frac{40400}{y}-404-1433\right)=\frac{10102}{1837}\left(\frac{40400}{y}-1837\right).$$

Putting y successively 1, 1·5 and 2, we obtain the Tables XVII, XVIII and XIX, which represent the distribution of pairs of siblings in the random samples of communities having the above percentages of "insane" members.

The values of the correlation for these fourfold tables were deduced in the usual way, leading to the following equations:

From Table XVII:

$$1{\cdot}888{,}709=r+2{\cdot}828{,}617r^2+3{\cdot}614{,}971r^3+1{\cdot}664{,}380r^4+{\cdot}009{,}379r^5$$
$$+{\cdot}719{,}313r^6+{\cdot}700{,}852r^7+{\cdot}000{,}575r^8, \qquad r={\cdot}51.$$

* Thus a family of ten with three insane, seven sane members, provides six pairs of siblings both insane, 21 pairs with first sibling sane and second insane, 21 pairs with first sibling insane and second sane, and 42 with both sane, or 90 sibling pairs in all.

From Table XVIII:

$$1{\cdot}347{,}845 = r + 2{\cdot}475{,}511r^2 + 2{\cdot}601{,}761r^3 + {\cdot}785{,}249r^4 + {\cdot}040{,}096r^5 + {\cdot}687{,}312r^6 + {\cdot}294{,}567r^7 + {\cdot}056{,}523r^8, \qquad r = {\cdot}47.$$

From Table XIX:

$$1{\cdot}055{,}187 = r + 2{\cdot}228{,}306r^2 + 1{\cdot}991{,}361r^3 + {\cdot}393{,}986r^4 + {\cdot}125{,}342r^5 + {\cdot}582{,}961r^6 + {\cdot}112{,}945r^7 + {\cdot}130{,}567r^8, \qquad r = {\cdot}44.$$

and if we extrapolate for a percentage of 2·5, we should have $r = {\cdot}41$.

TABLE XVII. *Complete Table for Fraternal Heredity. Tainted and Untainted Stocks. On* 1 °/₀ *Basis.*

Second Sibling.	First Sibling. Insane	Not Insane	Totals
Insane ...	250	1681	1931
Not Insane	1681	218555	220236
Totals	1931	220236	222167

TABLE XVIII. *Complete Table for Fraternal Heredity. On* 1·5 °/₀ *Basis.*

Second Sibling.	First Sibling. Insane	Not Insane	Totals
Insane ...	250	1681	1931
Not Insane	1681	144498	146179
Totals	1931	146179	148110

TABLE XIX. *Complete Table for Fraternal Heredity. On* 2 °/₀ *Basis.*

Second Sibling.	First Sibling. Insane	Not Insane	Totals
Insane ...	250	1681	1931
Not Insane	1681	107472	109153
Totals	1931	109153	111084

In dealing with pulmonary tuberculosis Pearson found that if the record of the tuberculous stocks was completed by allowing $\frac{1}{3}$rd instead of the recorded $\frac{1}{4}$th of the sibship to be ultimately tuberculous the value of the correlation was raised ·15. It is of very great importance that complete family records of insane sibships should be collected, giving the history of each member till death. In our incomplete records we find $\frac{1}{5}$th to $\frac{1}{4}$th insane, and although they are more complete than in the case of tuberculosis we have seen that the number of the insane is correlated with the age of the eldest member, and accordingly there is little doubt that the above values are too small. Probably the proportion of insane in the complete record would be at least $\frac{1}{4}$th to $\frac{1}{3}$rd of the sibship, and we might then fix the value of fraternal resemblance as lying according to the percentage assumed for the general population between ·45 and ·55.

The following table gives a general summary of results so far reached:

TABLE XX. *Fraternal Resemblance.*

Character	Source of Data	Computer	Intensity
Pathological:			
Pulmonary Tuberculosis	Crossley Sanatorium	Pearson	·48
Deaf-Mutism	Dr Fay's Data	Schuster	·73
Insanity	Dr Urquhart's Data	Heron...	·45—·55
Physical:			
Cephalic Index ...	Pearson, School Data	Lee and Pearson ...	·43—·54
Head Height	„ „	„ „ ...	·49—·55
Stature	Pearson, Family Measurements	Pearson and Lee ...	·51—·55
Forearm	„ „ „	„ „ ...	·44—·51
Span	„ „ „	„ „ ...	·53—·56
Eye-Colour	Galton, Family Data	Pearson	·44—·52
Psychical:			
Intelligence	Pearson, School Data	Pearson and Lee ...	·44—·46
Handwriting	„ „	„ „ ...	·48—·53
Intelligence	Oxford Class Lists	Elderton and Schuster	·52—·61

It will be seen that the resemblance in the case of the insane diathesis fits in well with the other data. The one really discordant result is that for deaf-mutism, which stands much above any value hitherto noted in the case of man*.

We may conclude that the resemblance of brothers in the character "insane diathesis" is, within the limits of incompleteness of record, well in accordance with the system of values found for other characters, whether physical or psychical.

* I have not succeeded in finding any important slip in Mr Schuster's analysis, but I note that he has based this part of his inquiry on the brothers and sisters of a *married* deaf-mute, which may to some extent have influenced selectively his result.

(8) *Fertility of Insane Stocks.* In 331 families or sibships* containing at least one insane member, the gross fertility distribution was found to be as follows:

TABLE XXI. *Fertility of Insane Stocks.*

Size of Family	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
No. of Families	16	48	44	34	51	35	39	39	21	11	11	6	6	1	1	1	331

The statistical constants of this distribution are as follows:

$$\text{Mean Size of Family} = 5{\cdot}97 \pm {\cdot}11.$$
$$\text{Standard Deviation} = 2{\cdot}93 \pm {\cdot}08.$$

The fact that insanity is a disease of adult life makes us fairly certain that the above families are practically completed. The stocks being middle class, we see at once that the fertility is high, and this is to be emphasised because no limit of duration of marriage has been taken, and no limit to the ages of parents upon marriage. Pearson, dealing with fertile English marriages, begun when both parents were at or under 35, and lasting at least 15 years has found an average gross family of 6·58, or only about half a child more than in the case of these marriages of insane stock, which may have, and undoubtedly have in certain cases, been started after 35 and have lasted less than 15 years. From the above result it will be clear that insane stocks are as fertile as and possibly more fertile than any other stocks in the community.

Even more important than the fertility of insane stocks is the fertility of marriages in which one parent has at one or other time been insane. From Dr Urquhart's data we find 87 such cases, in 48 of which the father, and 39 of which the mother, has been insane. The actual distribution of these 87 families is given in Table XXII:

TABLE XXII. *Fertility of Insane Persons.*

Size of Family	1	2	3	4	5	6	7	8	9	10	11	12	13
Frequency	5	13	9	14	12	8	8	4	5	7	—	—	2

From this we find:

$$\text{Mean Size of Family} = 5{\cdot}18 \pm {\cdot}21.$$
$$\text{Standard Deviation} = 2{\cdot}84 \pm {\cdot}15.$$

Now 5·18 is precisely the value found by Westergaard for the professional classes in Copenhagen in the case of marriages which have lasted *at least fifteen years* and for a race more fertile than the Scottish. We have also to remember (i) that the

* This word is used in the sense of groups of brothers and sisters the offspring of a single pair.

marriages of our insane persons have not been completed nor necessarily lasted even 15 years, (ii) that for a period, and in many cases a long period, the marriage has been interrupted by the confinement of one member in an asylum, and (iii) that the expectation of life of the insane is far less than that of the sane. Table XXIII gives the actual distributions for the purposes of comparison reckoned on the basis of 1000 individuals.

It will be seen that our present statistics amply confirm the general result reached by Pearson* that pathologically abnormal stocks, or stocks tainted by deaf-mutism, tuberculosis, albinism, mental degeneracy, criminality, etc., are not less but rather more fertile than the normal stocks in the community. The eugenic importance of this in

TABLE XXIII. *Comparative Fertility in Insane and Normal Stocks.*

Size of Family	Dr Urquhart's Data		Karl Pearson's Data		Copenhagen Data. Marriages of Professional Class lasting at least 15 years	Pearson, Peerage Marriages of at least 15 years
	Insane Stock	Insane Parent	Family Schedules	Marriages of 15 years begun at or before 35		
1	48	57	87	34	83	49
2	54	150	91	56	113	76
3	124	103	122	84	151	101
4	103	161	132	103	125	138
5	154	138	113	124	127	150
6	106	92	135	115	107	96
7	118	92	83	122	75	114
8	118	46	81	104	74	94
9	64	58	77	64	51	66
10	33	80	35	76	38	45
11	33	—	21	51	21	29
12	18	—	9	26	19	26
13	18	23	9	24	7	10
14	3	—	4	7	6	2
15	3	—	1	4	1	3
16	3	—	—	3	1	0
17	—	—	—	1	—	1
18	—	—	—	1	1	—
19	—	—	—	1	—	—
Total	1000	1000	1000	1000	1000	1000
Mean	6·0 ± ·11	5·2 ± ·21	5·3 ± ·07	6·6 ± ·06	5·2 ± ·05	5·8 ± ·07
Standard Deviation	2·93 ± ·08	2·84 ± ·15	2·87 ± ·05	3·06 ± ·04	2·99 ± ·04	3·14 ± ·05

relation to the insane diathesis is self-evident, for within the community natural selection is largely suspended, and the "insane" restored to family life as recovered. It would be of great value to have full statistics of the length and number of attacks

* See Pearson: *The Scope and Importance to the State of the Science of National Eugenics*, Boyle Lecture, Oxford University Press, Table IX, p. 35.

of the individual insane, so that some measure might be made of the population which fluctuates between the asylum and civil life. Full information will probably be only forthcoming when the General Register of the Insane referred to earlier in this paper is an accomplished fact.

(9) *Distribution of Insanity within the Sibship.* We now reach the investigation of a point not without difficulty, but of the greatest interest both from the standpoint of any theory of inheritance and from eugenic considerations. In tainted stock does the taint tend to become active in any correlation with the order of birth? According to the statistics of Pearson for tuberculosis and of Goring for criminality these pathological conditions are more evident in the earlier than the later born members of the stock. Does the like state of affairs exist in the case of insanity?

The point at which we have to be cautious is the doubt whether the apparent heavy incidence on the elder-born as compared with the younger-born is spurious and due to the fact that the population of the asylums is not a purely random sample of the general population. On the one hand the elder siblings reach the danger zone sooner than the younger, but as they pass through the asylum and die sooner than the younger it is not obvious that on this account we should expect to find in a given group of patients a larger proportion of elder siblings. In order to throw light, however, on this point, a correlation table was formed of the age of patients and their birth order in the family. The result was:

$$r = -\cdot 05 \pm \cdot 04.$$

If this were significant, the older the patient the slightly more likely he was to be born early in the family. But it is obvious that the correlation, having regard to its probable error, is of no significance, or that the age of the patient when the record was made had no relation to his order of birth. It does not therefore seem likely that the younger patients in the asylums represent a large number of early-born siblings just reaching the danger zone.

Taking any set of families in which at least one member of each family is marked with a certain characteristic, let there be f_s families of s members, s running from 1 to the maximum fertility p. In the f_s families of s, let F_s members be marked with the character in question. Then $f_1 = F_1$ and f_s will be equal to or greater than F_s.

Now if we assume that the marking is independent of the position in the family, we must have f_1 first born arising from the families of one. Of the F_2 marked individuals $\frac{1}{2} F_2$ will be first born and $\frac{1}{2} F_2$ second born; and generally the F_s marked individuals in families of s will provide F_s/s individuals in each birth position from 1 to s.

Accordingly the total number of first born will be $\sum_{s=1}^{s=p} (F_s/s)$, and of qth born $\sum_{s=q}^{s=p} (F_s/s)$.

Now let the total population consist of MN individuals made up of complete family groups. Then the number of first born will be $n_1 = \sum_{s=1}^{s=p}(f_s)$ and the number of qth born will be $nq = \sum_{s=q}^{s=p}(f_s)$. If M of the total population be marked with some characteristic which is independent of (a) size of family and (b) position in the family —that is, if all the MN are equally likely to be marked, then the number of marked first born is clearly n_1/N and of marked qth born n_q/N. Thus the distribution of order of birth among the marked population will be the same as that of the total population. But will the distribution of size of families be the same, if these families are selected by being the sibships of marked individuals? Clearly not, because large families will have more marked members and be more often likely to occur in the record, i.e. the large families are weighted in our returns, if we do not confine our attention to one member of each family. Analytically we can proceed as follows: taking the f_s families of s, there will be f_s/N tainted families and $f_s(1-1/N)$ untainted. The chance that no one member of a family of s members should be tainted is clearly $f_s(1-1/N)^s$, or the number of tainted members would be $f_s\{1-(1-1/N)^s\}$. In other words this family would be reckoned this number of times, if we simply enquired as to size of family of each patient without investigating how far the patients were siblings. The distribution of the size of families would then be

$$f_1\{1-(1-1/N)\}+f_2\{1-(1-1/N)^2\}+f_3\{1-(1-1/N)^3\}+\ldots\ldots+f_p\{1-(1-1/N)^p\},$$

and depend upon the extent of the marked character in the population. If the marked character be like insanity relatively rare, we may neglect $(1/N)^2$ and the distribution becomes

$$\frac{1}{N}(f_1+2f_2+3f_3+\ldots+pf_p),$$

differing widely from the unselected distribution of $f_1+f_2+f_3+\ldots+f_p$ by emphasising the large families.

This weighting of the large families when we select by a marking has been considered in another aspect by Pearson, namely in the inheritance of fertility, where the big families are emphasised in a random sample of the population, and in determining the real mean, the variability and the inheritance coefficient for fertility, allowance has to be made for it*. But this source of disturbance has no existence in our data if we confine our attention to distinct family histories and not to distinct insane individuals; the patient being the member of the sibship for whom the record was originally made.

The first point to be answered is: Does the distribution of siblings, i.e. frequency of first, second, third, fourth, etc. members of the family differ essentially in insane stocks from the distribution of normal stocks? Table XXIV gives the distribution

* Pearson, "Mathematical Contributions to the Theory of Evolution. VI. On Genetic (Reproductive) Selection," *Phil. Trans.* Vol. 192 A, pp. 261 et seq.

according to position in the family of 1000 individuals taken out of (*a*) families in the Peerage (Pearson), (*b*) insane stocks, (*c*) Pearson's selected marriages, i.e. those begun at or before 35 and lasting at least 15 years. It will be noticed that the average fertility of (*b*) lies between (*a*) and (*c*) and consequently we should expect (*a*) to have more elder and fewer younger sons than (*b*), while (*b*) would have more elder and fewer younger sons than (*c*).

A comparison of results shows us that there is nothing anomalous about (*b*); it may well be the distribution of offspring of any normal class of which the mean size of family is 6·0. Insane stocks as such seem to have no abnormal distribution of offspring. They form in themselves a proper norm to compare the distribution of

TABLE XXIV. *Distribution of Order of Birth in various Classes for a sample of* 1000 *individuals.*

Order of Birth	(*a*) Peerage	(*b*) Insane Stocks	(*c*) Selected Marriages	(*d*) Actually Insane
1	171·6	167·5	151·8	230·8
2	163·2	159·5	146·7	170·9
3	150·2	150·4	138·2	166·7
4	132·8	129·6	125·4	151·7
5	109·1	112·4	109·8	87·6
6	83·4	86·6	90·9	70·5
7	66·9	68·8	73·5	40·6
8	47·4	49·1	55·0	29·9
9	31·2	29·3	39·2	27·8
10	19·9	18·6	29·4	10·7
11	12·2	13·1	17·9	6·4
12	7·2	7·5	10·2	4·3
13	2·7	4·5	6·2	2·1
14	1·0	1·5	2·6	—
15	·7	1·0	1·5	—
16	·2	·5	·9	—
17	·2	—	·5	—
18	—	—	·3	—
19	—	—	·1	—

insane individuals with. We see at once from column (*d*) that this latter is of a wholly different character. The incidence of insanity is most heavy on the earlier born members of the family. The comparison of the distribution of order of birth among the insane members of insane stocks with the general distribution of all members of such stocks is made in Table XXV.

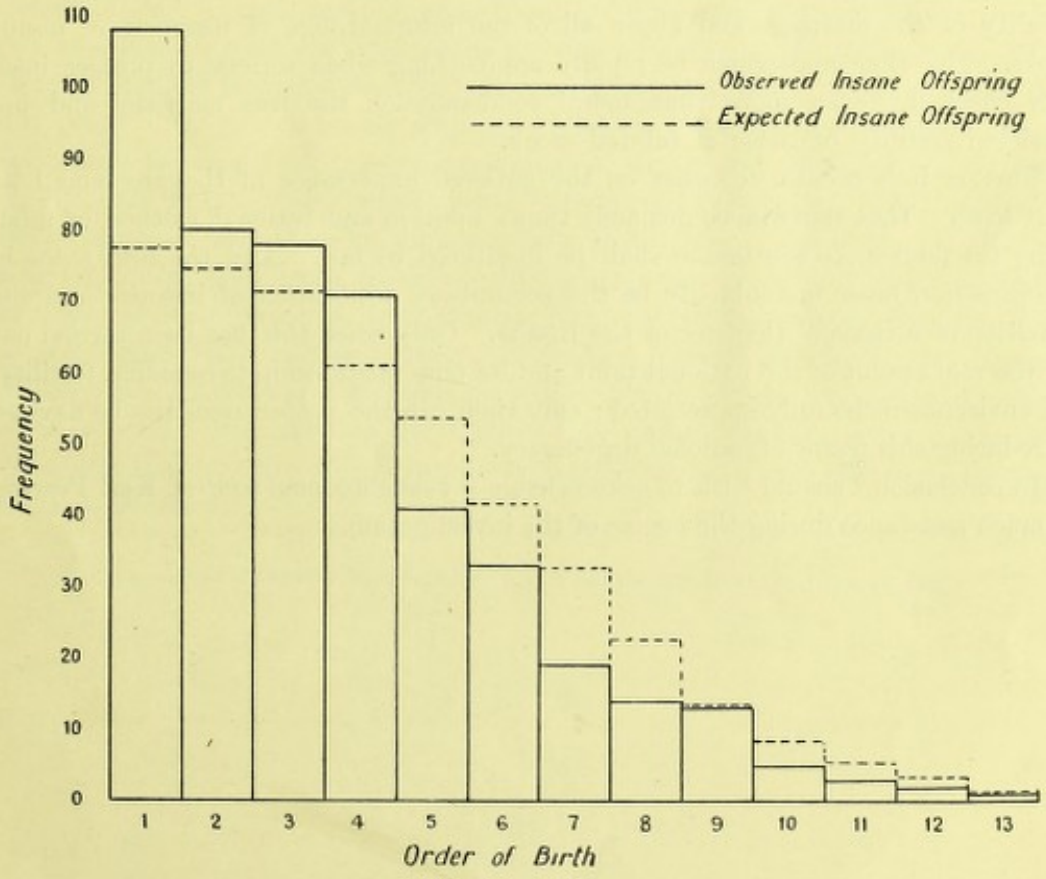
Thus the four eldest are in excess and all the others in defect among the insane. This anomalous condition is shown in the accompanying diagram. If we judge the matter analytically by calculating χ^2 to test the goodness of fit* we find $P = \cdot0013$, or the odds are nearly 1000 to 1 against the insane being a random sample from insane stock. We are compelled to suppose that insanity more often appears among the earlier born, corresponding in this respect to pulmonary tuberculosis and criminality†.

* *Biometrika*, Vol. I. p. 155. † Pearson, Boyle Lecture, p. 43.

If we suppose that the difficulty of the earlier labours, which is admitted, is in some way correlated with brain injury, it would be more natural to suppose it to lead to idiocy than insanity of the forms with which we are dealing. And the like cause would hardly explain the increased liability of the earlier born members of a family to pulmonary tuberculosis. Whatever may be the actual source of the matter, there appears now to be considerable evidence to show that pathological defect occurs more frequently in the earlier born members of a family than in the later members.

TABLE XXV. *Distribution of Siblings.*

Order of Birth	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
Frequency, Insane Stocks	315	305	291	249	219	171	134	93	55	35	22	14	5	1908
Expected frequency of Insane Members	77·3	74·8	71·4	61·1	53·7	41·9	32·9	22·8	13·5	8·6	5·4	3·4	1·2	468
Actual Frequency of Insane Members	108	80	78	71	41	33	19	14	13	5	3	2	1	468
Defect ...	−30·7	−5·2	−6·6	−9·9	+12·7	+8·9	+13·9	+8·8	+0·5	+3·6	+2·4	+1·4	+0·2	—



(10) *Conclusions.* Data such as those on which this memoir is based are now being put on record in more than one asylum, and we may hope shortly for a considerable broadening of the basis upon which the present conclusions are built. But even with the present material, very definite statements can be made. There is a close correspondence between the inheritance of the insane diathesis and that of pulmonary tuberculosis. In fact it appears highly probable that the tendency to pathological defects generally is inherited in man in precisely the same manner as are physical and psychical characters. Further there is no reduction in, possibly rather an augmentation of, the fertility of insane stocks, when compared with that of sane stocks. The incidence of insanity does not appear to be equally distributed over the family, but to fall more heavily on the elder members. All these results are of vital importance from the standpoint of national eugenics. The tendency of pathological defect to be associated more intensely with the earlier born is a very strong argument against the restriction of the family. The normal, or probably more than normal fertility of the insane, notwithstanding their partial seclusion and high death-rate, and the fact that insanity is a disease largely of middle life, must make us pause before we acquiesce in the unrestricted return of the "recovered" insane to family life; while the definite inheritance of insanity which is here demonstrated, an inheritance as intense as that of deaf-mutism or the tubercular diathesis, must surely raise the question of the morality of the marriage and above all of the intermarriage of members of insane stocks. The time appears to be rapidly approaching when society to protect itself shall check by even more than moral condemnation the free marriage and unrestricted fertility of those of tainted stock.

Further it is needful to insist on the national importance of the problems here dealt with. That importance demands that a uniform and rational method of tabulating the facts as to the insane shall be instituted by law. And the first steps in this direction must undoubtedly be the compulsory notification of insanity and the formation of a General Register of the Insane. Only when this has been carried out can the real extent of the national taint and its true relationship to heredity, fertility, and environment be fully appreciated; only then can the proper remedies be devised for reducing this factor of national degeneracy.

In conclusion I should wish to acknowledge my indebtedness to Prof. Karl Pearson for much assistance during the course of the investigation.

APPENDIX.

EVIDENCE FROM FAMILY RECORDS.

The actual determination of the percentage of insane offspring of insane parents, can only be made when the offspring of insane parents have been followed completely through the danger zone. In the present memoir the number of insane offspring has had to be judged from the number of insane in the sibships of which one person is insane. The value of the percentage of the insane is therefore on this account exaggerated, as an insane parent might have all the offspring sane; but on the other hand it is minimised because at the time of the record the offspring of our insane parents are not wholly through, nay, many members have often not reached, the danger zone. Pearson's Family Records (Samples of General Population)* contain 17 cases of one or both parents being insane. There is only *one* family in this series in which all members lived to be 50 without a single case of insanity; thus it is very unlikely that the introduction of such families would sensibly affect the result given of 25 p.c. of insane offspring. Pearson's Family Records give 66 p.c. offspring insane where both parents are insane, 40 p.c. insane when one parent only is insane, and 44 p.c. insane when one or both parents are insane. In estimating these percentages, only those children surviving to 50 years of age without exhibiting insane tendencies are classed as sane. The average number of children per family who either became insane or lived sane to 50 is 4·6. These results, which will be ultimately more fully discussed when the Family Records are dealt with, appear to indicate that, if *completed* histories are taken, 40 p.c. of insane offspring of insane parents is not an over-estimate and that in this memoir we have erred on the side of lessening the intensity of inheritance in taking 25 p.c. of the offspring of insane persons to be insane.

* Using ancestral generations, where the bulk of individuals are dead or over 50 years.

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