

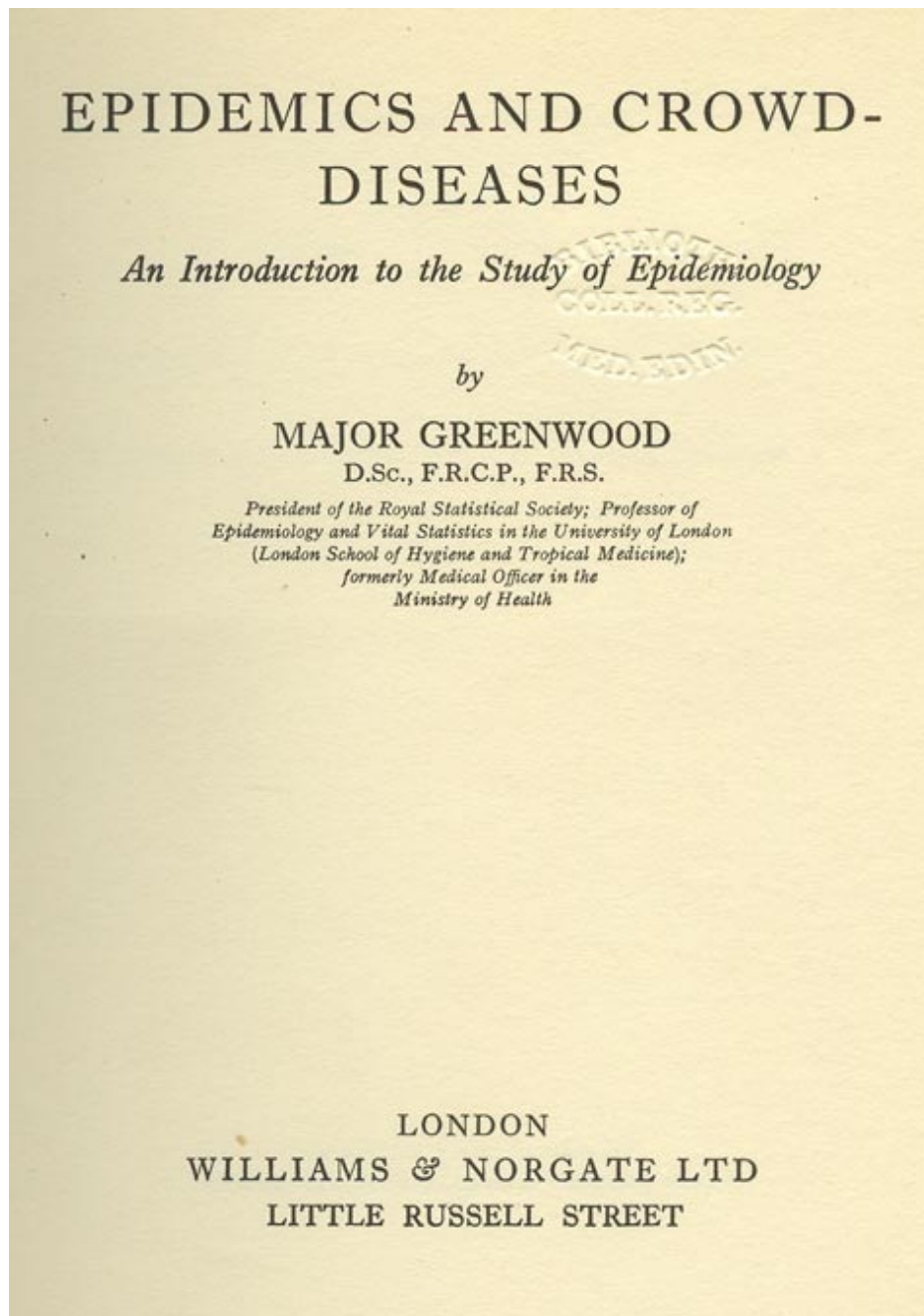
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[Greenwood M \(1934\)](#). Epidemics and crowd-diseases. Oxford: Oxford University Press.

Title pages



Key passages

What are the necessary and sufficient conditions for believing that an immunizing process diminishes the risk either of taking a disease if exposed to risk or of dying of that disease if it has been contracted, below the average measure of such risk run by persons not artificially immunized?

The solution of this apparently simple problem is beset with difficulties of two kinds, material and formal. In real life the material difficulties are almost insuperable, as we shall see; for the moment I postpone them, and suppose that the groups we have to compare are alike in all respects save two: they are alike in age constitution, sex constitution, race, social class, in *all* environmental circumstances; they differ only in respect of having been or not having been immunized, and, in the character we desire to measure, viz. their group reaction in face of the disease. On these assumptions our difficulties are only formal or analytical, viz. how the alleged advantage is to be measured.

In this ideal case the data are that n_1 vaccinated persons have been exposed to the same risk as n_2 persons not vaccinated, that m_1 of the former and m_2 of the latter have been attacked, or, alternatively, have died, and that m_1/n_1 is smaller than m_2/n_2 ; we may further suppose that neither n_1 nor n_2 is a very small number, and that the ratios of m_1 to n_1 and of m_2 to n_2 are also not very small. This means that the scale of our experiment runs at least to some hundreds, and that the attack (or fatality) rate of the unimmunized is of the order of 10 per cent or more. Since we are building a castle in Spain we can afford to be generous in our contractor's estimate, and may, temporarily, require another luxury, viz. that the attack (or fatality) rate upon unimmunized persons has been ascertained independently of this particular experiment from a very large experience of unimmunized persons *in pari materia* with the subjects of our experiment.

Anybody who has read an elementary textbook of statistical methods will say that the treatment is simple. If the immunizing process were really ineffective we should expect $m_1/n_1 - m_2/n_2$ to be, on the average, zero, but we should expect "chance" to induce fluctuations around that expected value; we should not, however, expect such chance deviations to exceed in magnitude two or three times the *standard deviation* of sampling, which is

$$\sqrt{\frac{p(1-p)(n_1+n_2)}{n_1n_2}}$$

where p is the attack (or fatality) rate on unimmunized persons in general. If the difference *does* exceed a fairly small multiple of this quantity, then it is improbable that if the immunized and unimmunized *were* equally liable to attack or death we should have found so large a difference between their reactions and easier to believe that the immunizing process was responsible for the difference than that the difference was a mere chance happening.

