

Diagnosing overdiagnosis: conceptual challenges and suggested solutions

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Introduction

Overdiagnosis is a fundamental challenge to modern health care [1]. It is claimed to be “the biggest problem posed by modern medicine” [2], leading to unnecessary suffering and significant costs [1]. In the USA it is estimated that it results in more than \$200bn wasted on unnecessary treatment every year [3], and that 30 % of the health care spending is on ineffective measures [4, 5].

Many drivers of overdiagnosis have been identified (Fig. 1). The main challenges with overdiagnosis are: unnecessary diagnosis (including anxiety and reduced quality of life), unnecessary treatment (including harms and adverse side effects), allocation of scarce resources (including opportunity cost), professional integrity, and potential reduced trust in the health care services.

Although overdiagnosis has been identified in a variety of fields [1], we have witnessed vast and vivid debates on its extension and significance. E.g., in mammography screening, the estimates of overdiagnosis vary from 0 to 57 % [6–8]. Even overdiagnosis estimates from the same screening program vary significantly (10–25 %) [9, 10]. As no agreement is reached, ranges of overdiagnosis have been suggested [11].

One reason for such disagreement is a wide variety in interpretations of the concept of *overdiagnosis*. Overdiagnosis is commonly defined as diagnosing a person without

symptoms with a disease that will never cause symptoms or death during the person’s lifetime [1, 2, 8, 10, 12–15]. So defined, overdiagnosis will never cause any practical problems, because it is an idealised term that is impossible to measure [12]. We never know prospectively which instances will cause symptom or death during a person’s lifetime. Hence, a first step towards a more coherent and effective effort to address the problem of futile and harmful diagnostics would be to clarify the concept of overdiagnosis.

Accordingly, the purpose of this article is to analyse and specify the concept of overdiagnosis. First, some synonyms and related terms will be sorted out. Then a semantic analysis will explicate why a current diagnosis can never be characterized as an overdiagnosis, and hence why overdiagnosis does not exist (in presence). The analysis will uncover a series of tricky assumptions in the current common conception of overdiagnosis. It presupposes prophetic abilities, counterfactuals, a definite concept of disease, and a deterministic conception of causality. In order to avoid such challenges, a more differentiated nomenclature is suggested.

Many terms and many concepts

Several terms are used in the literature to discuss the phenomenon broadly labeled overdiagnosis. Table 1 lists some of the synonyms of overdiagnosis and some related terms, sometimes confused with overdiagnosis.

The term overdiagnosis also expresses several meanings. As within breast cancer screening the Marmot report highlighted 4 different interpretations [12, 13], and de Gelder and colleagues identified seven distinct meanings of overdiagnosis [8]. Hence, the term overdiagnosis is not

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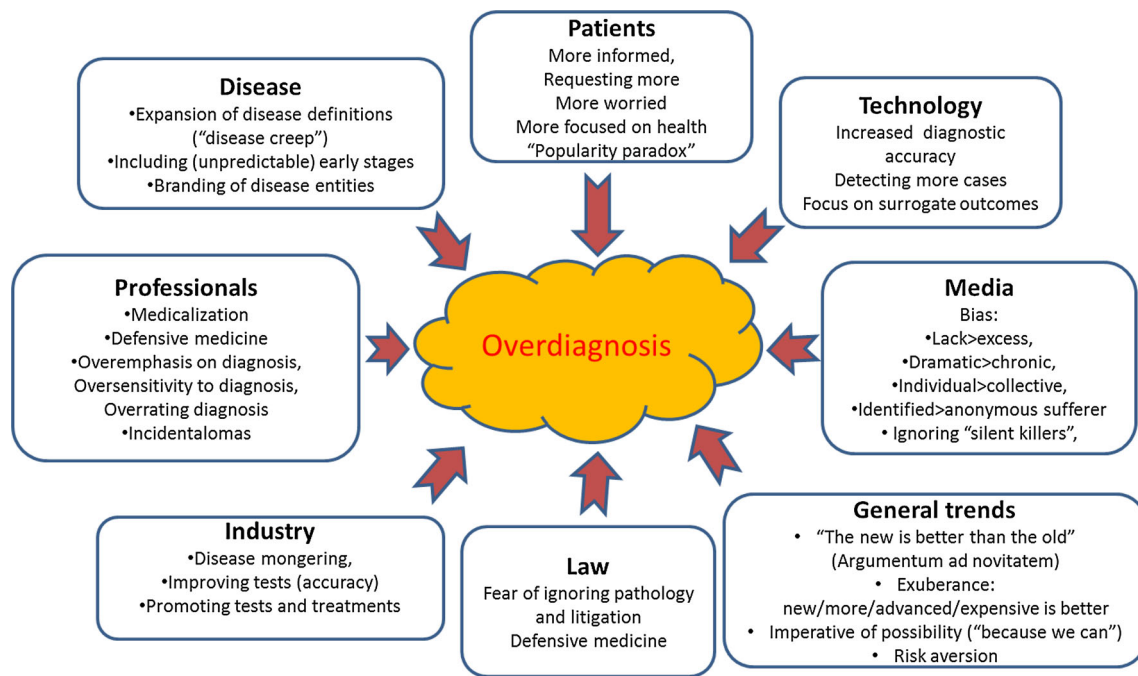


Fig. 1 Drivers of overdiagnosis

Table 1 Synonyms to overdiagnosis and related terms

Synonyms	Related terms
(Iatrogenic) pseudodisease	Misdiagnosis
Overdetection	Overtesting
Clinically irrelevant conditions	Incidentalomas
Finding conditions that not need to be found	Hidden false positives
Lanthanic disease	Diagnostic creep
Identifying benign “abnormalities”	False (negative/positive) test results

only used to express one meaning, but several concepts. This complexity may explain some of the controversies on overdiagnosis, but not all.

Although the many meanings of overdiagnosis could stem from various meanings of the term diagnosis, an analysis of the concept of diagnosis is beyond the scope of this article. Here diagnosis is defined as an identification of a bodily or mental condition, e.g., by symptoms, para-clinical signs, or markers, which are considered to be of disadvantage or harm to a person’s health.

A semantic problem

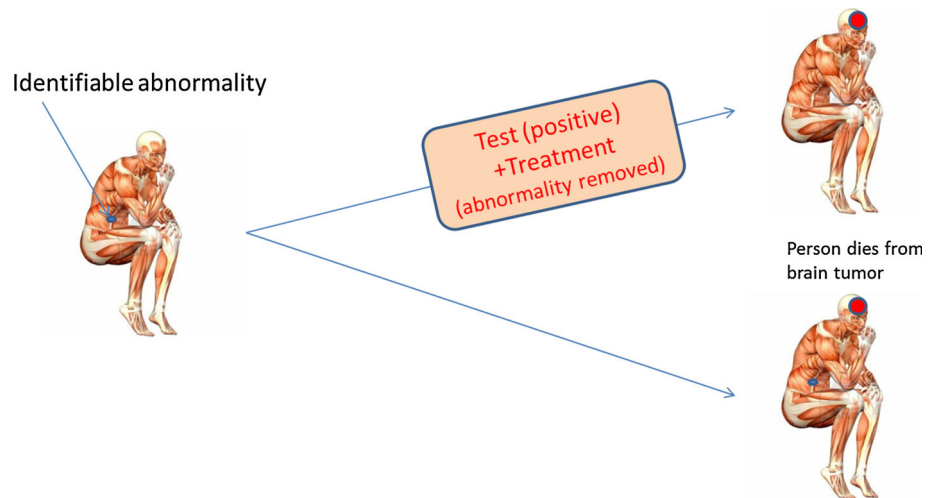
A semantic problem with the term overdiagnosis can be identified in the prefix *over*. The result of a (positive) test is a real diagnosis, and not a false positive test result. The

person definitely has the identified conditions. As long as it is not possible to say whether the person will ever experience or die from the condition that is diagnosed (during the persons’ lifetime, if the person is left untreated), or is prevented from dying from the disease (if the person is treated), it is not an *overdiagnosis*. It may be argued that it would be an overdiagnosis if it was possible to differentiate those cases that are harmful from those who are not, e.g., by some kind of extended predictive test. However, in that case only the malign cases would fall under the diagnosis, while the benign cases would not. Hence, there would be no overdiagnosis.

Tricky definitions

The term overdiagnosis can be traced back to the 1970s [16], but its explicit definitions are inspired by definitions of the synonymous term pseudodisease [17, 18]. Most recent publications refer to seminal definitions by Black and Welch [15, 19]. In these publications overdiagnosis is commonly defined as *diagnosing a person without symptoms with a disease that will (ultimately) never cause symptoms or death during the person’s lifetime* [1, 2, 8, 10, 12, 13, 15]. The content of the definition is illustrated in Fig. 2. A person may have an abnormality that does not cause symptoms, but that is identifiable by some diagnostic test, e.g., a screening test. If the person is tested, the abnormality may be detected and treated. However, the

Fig. 2 Illustration of the concept of overdiagnosis



person dies of another disease, e.g., brain tumor, 5 years after the detected condition. If the person *would not have been* tested and treated, he would still have died of the brain tumor 5 years later. Then the person died with the detected condition, but not from it, and he was overdiagnosed. Brain tumor is used here as an illustration, but the person may of course die of old age or other diseases.

There are four basic problems with this kind of definitions: it presupposes prophetic abilities, counterfactuality, a factual and fixed conception of disease, and a deterministic concept of causality.

Operationalizing the common definition of overdiagnosis presupposes that you know what will happen to a person in the future. This is impossible (for most of us). Retrospective studies where we investigate a group of deceased persons to see if they have unnoticed conditions, and assess whether they would have been discovered by a (screening) test, if this had been performed at a relevant time earlier in life, would give a good approximation of the level of overdiagnosis in the past. Moreover, differences in retrospective probability estimates for tested and non-tested groups, may indicate levels of overdiagnosis. However, it would not be useful in order to assess current overdiagnosis [12].

Correspondingly, the common definition presupposes that you are able to know what happens in counterfactual cases, i.e., what would happen if a (condition diagnosed as a) disease was not detected. This challenge can be clearly seen in definitions such as: “Overdiagnosis is detection of a disease that in the absence of screening would not have been diagnosed in the patient’s lifetime” [20]. Counterfactuals are difficult to assess, as they presuppose that we know what happen in alternative scenarios, where all other factors are equal (*Ceteris paribus*), except for the detection and treatment of the condition. Although we can try to estimate this by comparing two groups, we cannot be certain that the groups satisfy the *C. paribus* criterion. This

challenge can easily be recognized in the vibrant debates on reference and control groups (as well as on denominators).

The common definition of overdiagnosis is also problematic as it presumes a factual and fixed conception of disease. How to define disease (entities) and where to set cut-off levels are normative issues that are not given by facts in nature [21–23]. Physical or mental conditions that can be identified by tests (prior to symptoms) are of interest because they can result in suffering in the future. However, for most cases we do not know in advance which cases will lead to suffering, or when and to what extent they will do so. Hence, the concept of overdiagnosis hinges on a concept of disease, which is considered to be normative and potentially vague, as it depends on normative notions of “the good life.”

The definition of overdiagnosis also presupposes a clear-cut concept of causation: “Overdiagnosis is the term used when a condition is diagnosed that would otherwise not go on to *cause* symptoms or death” [15]. However, how do we know whether a condition causes symptoms or death? Most clinicians and many epidemiologists have a probabilistic conception of causation, i.e., causation is given by an increase in correlation. We do not know whether a specific case of breast cancer was caused by a specific set of DCIS, but DCIS increases the chance of developing breast cancer. In short, if we do not know which instances of a detected condition that “cause symptoms or death,” we cannot assess overdiagnosis in a precise manner.

Hence, there are (at least) four basic problems with the common definition of overdiagnosis: it presupposes prophetic abilities, counterfactuality, a factual and fixed conception of disease, and a clear-cut concept of causality. As indicated, all of these assumptions are conceptually challenging.

This explains some of the controversies over measures of overdiagnosis in the literature. If the concept is not clear, we will never agree on its measures. It also indicates that it

is difficult to operationalize the standard definition of overdiagnosis. I.e., it may be better to provide operational definitions of overdiagnosis than to try to operationalize an ideal definition.

Suggested nomenclature

A nomenclature that tries to address the challenges revealed above and which allows practical measurements and hopefully more open discussions on overdiagnosis is suggested in Table 2. The categories referred to in Table 2 are explained in Fig. 3.

In a given population one will always find persons with detectable abnormalities. If we test (groups of) the population who have no symptoms (A and C in Fig. 3), we may find abnormalities and diagnose them with the disease at the time of early testing (A) or later (C). Some of the persons tested early (A) will not die from the disease (G) while others may still die from the disease (H), e.g., due to imperfect treatment methods. Of persons tested early, but where the disease was detected later (C), some die of the disease (F) and others die from other diseases (or from old age) (E).

Other persons may be diagnosed with the disease after appearing symptoms (B). These may die from the disease (J) or from other diseases (I). Additionally, there is a group who die from the disease even though it has not been detected by early testing or testing after symptoms (L), e.g., due to false negative test results. For the sake of completeness, people in the population die from many other diseases as well (K).

The suggested nomenclature on overdiagnosis has to be supplemented by other important measures. Table 3 suggests some of these measures.

Discussion

The suggested nomenclature, of course, does not solve all the problems with the common definition of overdiagnosis. However, dividing one ideal and “complex” concept into several and more explicit concepts, may make it easier to measure and address the challenges that are related to superfluous diagnostics. It may also relax the hefty controversies and contribute to a more joint effort to improve health.

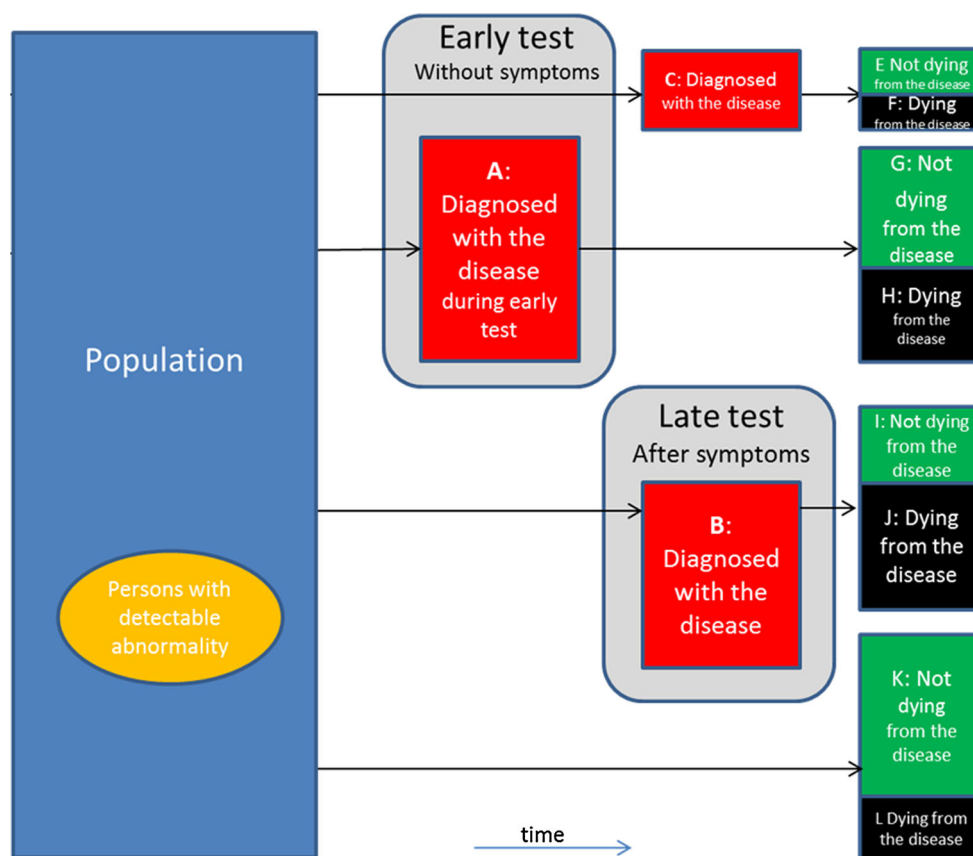
Terms are never neutral, so also for the suggested terminology. However, the suggested nomenclature provides measures for different outcomes of early testing and leaves more of the value judgments to the persons who consider to be tested.

The suggested terminology may still need contextual expansion. “Extra persons diagnosed” and “surplus diagnoses” may have different premises in large population based screening programs, in small targeted diagnostic test programs, and in opportunistic screening. This is only the first and general step towards a more coherent and unified terminology on overdiagnosis.

It can also be argued that the nomenclature is quite complicated, and as such has reduced value in clarifying oversignosis. However, as the debate on overdiagnosis well illustrates, overdiagnosis is a complex issue. The many controversies and heated disputes over appraising overdiagnosis

Table 2 Suggested nomenclature for addressing issues of overdiagnosis

Term	Explanation	Question addressed
Extra persons diagnosed = $A - B$	Number of extra persons that get the diagnosis (per 1,000) compared to the (untested) reference group during the test period	How many more persons got a diagnosis attributed to earlier testing?
Post-test Diagnosis Reduction = $B - C$	Reduced number of persons (per 1,000) diagnosed (after the early testing period) compared to the reference group in a given period of time (twice the length of what is stated to be the “early detection advantage”)	How many persons avoided a diagnosis later (after the early testing period) because the condition was discovered by the earlier test?
Surplus diagnoses = $A + C - B$	Long term extra number of persons (per 1,000) diagnosed with the disease attributed to early testing	How many more persons are identified (and treated) when using the early test than when not using an early test?
Non-reductive extra diagnosis, i.e., extra persons diagnosed without reduction in deaths = $E + G - I$	Number of extra persons that get the diagnosis (per 1,000) compared to the (untested) reference group that do not die from the disease	How many more of the persons who survive a diagnosis are there in the group with early testing compared to the group without early testing?
Reduced number of deaths attributable to early testing = $J - H - F$	How many fewer persons (per 1,000) die when early testing is performed than without early testing	How many lives were saved due to early testing?

Fig. 3 Scheme of categories of persons in cases of early testing**Table 3** Suggested nomenclature for addressing overdiagnosis related issues

Term	Explanation	Question addressed
Extra diagnosis per prevented death = $(E + G - I):(J - H - F)$	Extra persons diagnosed with the disease during early testing period (without reduction in deaths) for each extra death prevented by early testing	How many persons had an extra diagnosis for every person that is considered to be saved from dying from the disease?
Extra treatment per prevented death = $(A - B - C):(J - H - F)$	Extra persons diagnosed during early testing period and treated for the disease for each extra death prevented by early testing	How many extra persons had to be treated for the disease for every person that is considered to be saved from dying from the disease?

demonstrate that the subject matter is complex, and introducing simple concepts for complex issues may result in oversimplifications and fuel debates. As Fig. 3 illustrates, introducing early diagnosis (when people have no symptoms) generates complex situations and complicated assessments. It is very difficult to cover it all with one term, overdiagnosis. Instead, it appears to be more fruitful to use several specific terms to address the different issues, which on a generic level well may be called overdiagnosis.

Conclusion

The common definition of overdiagnosis is challenging as it is impossible to say whether a diagnosed person is

overdiagnosed or not. Moreover, it presupposes prophetic abilities, counterfactuality, a fixed concept of disease, and a deterministic concept of causality. In order to avoid these challenges, and to contribute to a more unified conception of overdiagnosis, an explicit nomenclature is suggested. Overdiagnosis is not only one thing, but several things, that have to be addressed separately. A more explicit terminology on overdiagnosis is important for measuring and addressing superfluous diagnostics and for more informed deliberation for those who are offered tests.

Conflict of interest I certify that there is no conflict of interest in relation to this manuscript, and there are no financial arrangements or arrangements with respect to the content of this manuscript with any companies or organizations. The manuscript is not published elsewhere.

References

1. Moynihan R, Doust J, Henry D. Preventing overdiagnosis: how to stop harming the healthy. *BMJ*. 2012;344:e3502. doi:[10.1136/bmj.e3502](https://doi.org/10.1136/bmj.e3502).
2. Welch HG, Schwartz L, Woloshin S. *Overdiagnosed : making people sick in the pursuit of health*. Boston: Beacon Press; 2011.
3. Berwick DM, Hackbarth AD. Eliminating waste in US health care. *JAMA*. 2012;307(14):1513–6. doi:[10.1001/jama.2012.362](https://doi.org/10.1001/jama.2012.362).
4. Bloche MG. Beyond the “R word”? Medicine’s new frugality. *N Engl J Med*. 2012;366(21):1951–3. doi:[10.1056/NEJMp1203521](https://doi.org/10.1056/NEJMp1203521).
5. Fisher ES, Wennberg DE, Stukel TA, Gottlieb DJ, Lucas FL, Pinder EL. The implications of regional variations in medicare spending. Part 2: health outcomes and satisfaction with care. *Ann Intern Med*. 2003;138(4):288–98.
6. Puliti D, Zappa M, Miccinesi G, Falini P, Crocetti E, Paci E. An estimate of overdiagnosis 15 years after the start of mammographic screening in Florence. *Eur J Cancer*. 2009;45(18):3166–71. doi:[10.1016/j.ejca.2009.06.014](https://doi.org/10.1016/j.ejca.2009.06.014).
7. Jorgensen KJ, Zahl PH, Gotzsche PC. Overdiagnosis in organised mammography screening in Denmark. A comparative study. *BMC Women’s Health*. 2009;9:36. doi:[10.1186/1472-6874-9-36](https://doi.org/10.1186/1472-6874-9-36).
8. de Gelder R, Heijnsdijk EA, van Ravesteijn NT, Fracheboud J, Draisma G, de Koning HJ. Interpreting overdiagnosis estimates in population-based mammography screening. *Epidemiol Rev*. 2011;33(1):111–21. doi:[10.1093/epirev/mxr009](https://doi.org/10.1093/epirev/mxr009).
9. Kalager M, Adami HO, Bretthauer M, Tamimi RM. Overdiagnosis of invasive breast cancer due to mammography screening: results from the Norwegian screening program. *Ann Intern Med*. 2012;156(7):491–9. doi:[10.7326/0003-4819-156-7-201204030-00005](https://doi.org/10.7326/0003-4819-156-7-201204030-00005).
10. Falk RS, Hofvind S, Skaane P, Haldorsen T. Overdiagnosis among women attending a population-based mammography screening program. *Int J Cancer*. 2013;133(3):705–12. doi:[10.1002/ijc.28052](https://doi.org/10.1002/ijc.28052).
11. Welch HG, Passow HJ. Quantifying the benefits and harms of screening mammography. *JAMA Intern Med*. 2014;174(3):448–54. doi:[10.1001/jamainternmed.2013.13635](https://doi.org/10.1001/jamainternmed.2013.13635).
12. Independent UK Panel on Breast Cancer Screening. The benefits and harms of breast cancer screening: an independent review. *Lancet*. 2012;380(9855):1778–86. doi:[10.1016/S0140-6736\(12\)61611-0](https://doi.org/10.1016/S0140-6736(12)61611-0).
13. Marmot MG, Altman DG, Cameron DA, Dewar JA, Thompson SG, Wilcox M. The benefits and harms of breast cancer screening: an independent review. *Br J Cancer*. 2013;108(11):2205–40. doi:[10.1038/bjc.2013.177](https://doi.org/10.1038/bjc.2013.177).
14. International Agency for Research on Cancer (IARC). *IARC handbooks of cancer prevention—breast cancer screening*. Geneva: World Health Organisation; 2002.
15. Welch HG, Black WC. Overdiagnosis in cancer. *J Natl Cancer Inst*. 2010;102(9):605–13. doi:[10.1093/jnci/djq099](https://doi.org/10.1093/jnci/djq099).
16. Grobin W. Diabetes in the aged: underdiagnosis and overtreatment. *Can Med Assoc J*. 1970;103(9):915–23.
17. Feinstein AR, Esdaile JM. Incidence, prevalence, and evidence. Scientific problems in epidemiologic statistics for the occurrence of cancer. *Am J Med*. 1987;82(1):113–23.
18. Morrison A. *Screening in chronic disease*. New York: Oxford University Press; 1985.
19. Black WC. Overdiagnosis: an underrecognized cause of confusion and harm in cancer screening. *J Natl Cancer Inst*. 2000;92(16):1280–2.
20. Etzioni R, Penson DF, Legler JM, et al. Overdiagnosis due to prostate-specific antigen screening: lessons from US prostate cancer incidence trends. *J Natl Cancer Inst*. 2002;94(13):981–90.
21. Hofmann B. *The technological invention of disease—on disease, technology and values*. Oslo: Universitetet i Oslo; 2002.
22. King L. What is a disease? *Philos Sci*. 1954;21:193–203.
23. Reznick L. *The nature of disease*. New York: Routledge & Kegan Paul; 1987.