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Assessing the sensitivity of STD surveillance in the Netherlands: an application of the capture–recapture method

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SUMMARY

The capture–recapture method was used to estimate the sensitivity of case finding in two national STD surveillance systems: (1) STD registration at municipal health services (STD-MHS); (2) statutory notification by clinicians (NNS). To identify those cases common to both surveillance systems, cases from 1995 were compared using individual identifiers. Estimated sensitivities for syphilis were: STD-MHS 31% (95% CI: 27–35%), NNS 64% (56–71%); and for gonorrhoea: STD-MHS 15% (14–18%), NNS 22% (19–25%). The combined sensitivity of both systems was 76% for syphilis and 34% for gonorrhoea. Differences in the sensitivity of the systems were significant. The NNS was more sensitive than the STD-MHS, and the identification of cases was significantly more sensitive for syphilis than for gonorrhoea. A stratified analysis showed comparable results for the two sexes. Knowledge on the sensitivity of surveillance systems is useful for public health decisions and essential for international comparisons.

INTRODUCTION

Surveillance data are the main source of information for infectious diseases in many countries. They form the basis for planning and evaluation of public health activities. The sensitivity of a surveillance system can be defined as the proportion of cases with a disease or health condition detected by the surveillance system and depends on the likelihood of a disease being recognized, diagnosed and reported [1]. It is low for diseases with a high proportion of asymptomatic infections as no medical examination will follow (e.g. *Chlamydia trachomatis* and *Neisseria gonorrhoeae* infections) and for diseases which are not diagnosed consistently on the basis of laboratory tests (e.g. gonorrhoea or herpes genitalis.)

Although it is common knowledge that many infectious diseases are underreported [2] the amount of underreporting is unknown for sexually transmitted diseases (STD) (e.g. syphilis and gonorrhoea). For The Netherlands it was shown that the sensitivity may vary for different STDs, and between urban and rural regions [3]. The sensitivity of the statutory notification system for gonorrhoea was estimated to be only 30% [3, 4]. Estimates of the sensitivity of other STD registrations are currently not available. Ideally, one would assess the completeness of surveillance of infectious diseases by comparing it with a 'gold standard' of disease incidence. Lacking this, the completeness may be estimated by using capture–recapture methods if a second independent data source exists [5–7].

We report on an evaluation of STD surveillance systems in The Netherlands. The main objective was to assess the sensitivity of two national STD surveillance systems by applying the capture–recapture method to syphilis and gonorrhoea cases identified by these surveillance systems.

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MATERIALS AND METHODS

STD surveillance systems

The national notification system (NNS), as in most European countries, is based on statutory notification by general practitioners and physicians, and includes gonorrhoea and syphilis. Confirmed cases of gonorrhoea and primary and secondary syphilis are notified anonymously. Data are available by date and place of reporting, gender, date of birth, and place of residence. Cases have to be confirmed by laboratory testing. The use of the notification data is limited due to an unknown amount of underdiagnosis and underreporting.

The STD registration at municipal health services (STD-MHS) is based on voluntary data collection by public-health nurses working in STD control in MHS and six STD clinics. This registration system collects information on the number of individuals attending municpial health services and STD clinics for an STD examination, HIV antibody test or STD/HIV counselling. Besides diagnosis also background variables are collected routinely including gender, age, nationality, country of birth, sexual orientation, history of STD, commercial sex, and drug use. Cases are defined on the basis of the diagnosis made by a medical doctor. Syphilis and gonorrhoea cases are confirmed by laboratory test.

Cases common to both surveillance systems were identified by comparing cases notified and reported in 1995. Notification records from 1994 and 1996 were also reviewed for individuals reported to the STD registration and who were not found in the notified cases of 1995. The individual identifiers used were date of birth, gender, municipal health service and place of residence. For the analysis of gonorrhoea the data from two cities had to be excluded ($n = 366$) as the dates of birth were missing in the STD-MHS.

Principles of the capture–recapture method

The capture–recapture method is a technique derived from ecology applied to epidemiological studies, especially to estimate the size of the case-population by analysing the degree of overlap between incomplete lists of cases from available data sources [8]. Patients are 'captured' by one data source and are 'recaptured' if they appear in a second independent data source. Patients are 'marked' by unique personal identifiers, such as name or date of birth. The capture–recapture method has a high potential to estimate the actual number of cases in the community from two or more independent surveillance sources and to evaluate the sensitivity of the surveillance systems [9]. To use the method appropriately the following requirements need to be fulfilled: (1) reports to the sources are made independently, that is reporting to one source does not affect the probability of reporting to the other; (2) all true matches and only true matches are identified; (3) all cases identified by the two surveillance systems are true cases that occurred in the population under investigation and within the appropriate time period (i.e. surveillance is highly specific); and (4) there is the same possibility for all cases to be identified in a source (similar catchability) [8, 9].

Capture–recapture for syphilis and gonorrhoea

In this study estimates of the total number of syphilis and gonorrhoea cases and the completeness of reporting were calculated by a two-sample capture–recapture method, which was described in detail by Hook and Regal [10]. The two surveillance systems STD-MHS and NNS are functionally independent. For this analysis they were considered as random capture samples in a given population. The principles are as follows: cases within the two sources are compared and those common to both systems ($X1/1$) are identified; the number of cases not identified in any of the systems ($X0/0$) can then be estimated as

$$X0/0 = \frac{X1/0 \times X0/1}{X1/1}, \tag{1}$$

where $X1/0$ and $X0/1$ are the number of cases found only in source one and source two, respectively (Fig. 1). These numbers can be entered into a 2×2 table as is shown in Figure 2. If the numbers in the cells are small, the following formula is preferred to get less biased estimates [11, 12].

$$N = \frac{(N_1+1)(N_2+1)}{X_{1/1}+1}, \tag{2}$$

$$\operatorname{Var} N = \frac{(N_1+1)(N_2+1)\,X_{1/0}\,X_{0/1}}{(X_{1/1})^2\,(X_{1/1}+2)}. \tag{3}$$

An additional analysis stratified for gender was performed to compare the levels of sensitivity in each strata for each surveillance system. Possible variation across strata for any data source gives an estimate for the representativeness of the data. The software programs SAS 6.11 and EpiInfo 6.04 were used for data handling and analysis.

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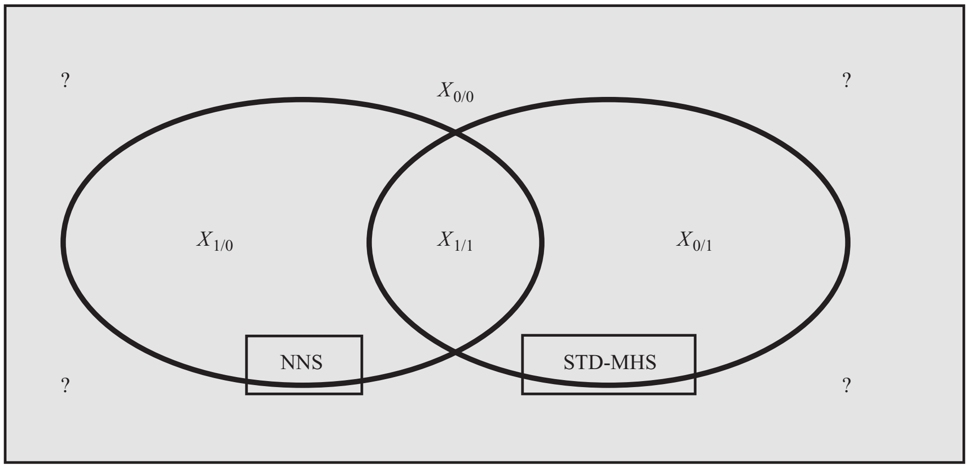

Fig. 1. Schematic description of the distribution of the total number of STD in The Netherlands.

		Source A +	Source A –	
Source B	+	$X_{1/1}$	$X_{0/1}$	N_2
	–	$X_{1/0}$	$X_{0/0}$	
+ Notified		N_1		N
– Not notified				

Fig. 2. Cases reported in two independent surveillance systems. Where:
$X_{1/1}$ = cases registered in source A and source B;
$X_{1/0}$ = cases registered in source A but not in source B;
$X_{0/1}$ = cases registered in source B but not in source A;
$X_{0/0}$ = cases *neither* registered in source B *nor* in source A;
N = all cases occurring;
N_1 = all cases recorded in source A;
N_2 = all cases recorded in source B.

Observed cases (n) = $X1/1 + X1/0 + X0/1$.
Total cases (unknown): $N = n + X0/0$.

RESULTS

In 1995, 204 cases of syphilis and 1425 cases of gonorrhoea were reported to the NNS (Table 1). In the STD-MHS 101 cases of syphilis and 917 cases of gonorrhoea were registered. Unfortunately, data on gonorrhoea from two cities (Rotterdam and The Hague) were incomplete and had to be excluded. The proportion of cases excluded from the national data sets was almost identical for both systems in Rotterdam (difference = 0·6 %) while it was larger for the NNS than for the STD-MHS in The Hague (difference = 7 %). Hence, 1059 cases of gonorrhoea from the NNS could be matched with 753 cases from the STD-MHS; for syphilis these figures were 204 and 101. The age distribution of the cases was comparable within different categories.

Syphilis

Based on 64 matches a total number of 318 actual cases (95 % CI: 286–362) of primary and secondary syphilis was estimated. Based on the analysis, the sensitivity of the NNS was estimated to be 64 % (95 % CI: 57–73 %), and of the STD-MHS was 31 % (95 % CI: 28–36 %) and of both systems combined it was 76 % (95 % CI: 67–86 %) (Table 2).

Gonorrhoea

Based on 162 matches a number of 4902 actual cases (95 % CI: 4288–5518) with gonorrhoea were estimated. The sensitivity of the NNS was 21·6 % (95 % CI: 19·2–24·7 %), and the sensitivity of the STD-MHS was 15·4 % (95 % CI: 13·7–17·5 %). The overall sensitivity of both systems was 33·7 % (95 % CI: 29·9–38·5 %) (Table 2).

The observed variations in the sensitivity for the two STD, including the combined sensitivity, and the variation between both systems are significant as indicated by the confidence intervals. After stratification for gender the estimated sensitivity of both systems remained unchanged (data not shown), For syphilis, the estimated total number of cases slightly decreased from 318 to 313. For gonorrhoea, the number slightly increased from 4902 to 4921. Thus, gender did not affect the sensitivity of the two surveillance systems for syphilis and gonorrhoea.

DISCUSSION

Surveillance of STD is an important and difficult task. Sensitivity is only one attribute by which surveillance systems are evaluated. Other relevant attributes are

Table 1. *Cases of syphilis and gonorrhoea notified in the national notification system (NNS) and at Municipal Health Services (STD-MHS), The Netherlands, 1995*

	Primary and secondary syphilis		Gonorrhoea*	
	NNS no.	STD-MHS no.	NNS* no.	STD-MHS* no.
Male	141	54	839	564
Female	63	47	220	189
Total	204	101	1059	753
Mean age males (in years)	37·2	35·7	32·0	32·0
Mean age females (in years)	28·4	25·9	28·0	27·1
Mean age sexes combined (in years)	34·5	31·1	31·2	30·8
Age span (in years)	15–17	16–58	15–75	15–75

* Data from Rotterdam and The Hague excluded.

factors as simplicity, flexibility, acceptability, representatives or timeliness [1]. However, reporting needs to be complete so that the data represent the population under surveillance. To estimate the sensitivity, exhaustive incidence studies can be conducted, but these are very costly and not feasible as a routine tool in evaluating surveillance data. Hence, the capture–recapture method may offer an alternative. The availability of two national surveillance systems for syphilis and gonorrhoea in The Netherlands allowed us to apply the capture–recapture method to estimate the sensitivity of surveillance for these STD. This was done after careful reviewing of the requirements for the capture–recapture method [9, 10].

The sensitivity of STD surveillance systems was demonstrated to vary significantly between different systems and also for different STD within the same system. The NNS appeared to be more sensitive than the MHS-STD and surveillance for syphilis revealed to be more sensitive than for gonorrhoea.

According to Papoz [13] no application of the capture–recapture methods can assess the exact number of individuals in the target population as underlying assumptions cannot be verified and are not completely fulfilled, and even the most enthusiastic proponents of the method, do not deny limitations [8, 14, 15]. These assumptions deal with the sample population and the sampling methods.

In reviewing the requirements and assumptions our main concern deals with the degree of independence of the two sampling frames. Truly independent data sources are rare [16]. Physicians who diagnose an STD patient and notify the case within the NNS may also refer the patient to the public-health nurse at a MHS for further counselling and contact tracing. This practice is infrequent (5%) [17]. However, referring at STD clinics occurs to an unknown extent. All this might lead to an increased number of matches and thus to an overestimate of the sensitivity of these systems.

The ability of a system to capture a case may differ for individuals within the population, since the individual who consults a physician for STD examination might not necessarily belong to the same 'subpopulation' of MHS attendees. If the two sampling frames are not entirely overlapping than a lower number of matches could be found and the sensitivity will be underestimated.

Misclassification may occur in only one register which will result in an underestimation of the number of matching pairs and thus of the sensitivity. The inclusion of laboratory confirmation in the case definitions of both surveillance systems ensured that all cases can be expected to be true cases, so that misclassification was assumed to be rare.

Matching relies on a number of identifiers like age, gender, date of birth or name, that describes individuals uniquely. These data are not always available in STD surveillance, since STDs are a sensitive issue, and confidentiality is taken seriously. We experienced this limitation mainly for the data on gonorrhoea from two cities where the dates of birth were incomplete. In the analysis these two cities had to be excluded. The number of cases excluded was proportionate for both pools in one city while in the other city the exclusion of gonorrhoea data resulted in the loss of a larger number of cases from the NNS. This may have resulted in an underestimate of the sensitivity of the NNS in comparison with the STD-MHS. As the overall undernotification for STD

Table 2. *Sensitivity of the national notification system (NNS) and the STD registration at Municipal Health Services (STD-MHS) for gonorrhoea and syphilis, The Netherlands, 1995*

	Number of cases observed					Sensitivity					
	NNS and STD-MHS ($X_{1/1}$)	NNS (N_1)	STD-MHS (N_2)	Total number of cases identified	Estimated number of total cases	NNS %	CI %	STF-MHS %	CI %	Combined NNS and STD-MHS %	CI %
Primary and secondary syphilis	64	204	101	241	318	64·2	57·3–72·8	31·4	28·1–35·7	75·5	67·4–85·7
Gonorrhoea	162	1059	753	1650	4902	21·6	19·2–24·7	15·4	13·7–17·5	33·7	29·9–38·5

surveillance is more common in cities [4, 18] the exclusion of the two cities may have resulted in an overestimate of the sensitivity.

Data quality is a point of concern regarding the accuracy of the matching process. The accuracy of data recording (e.g. date of birth) is double checked for the NNS only. To reduce the effect of errors in various variables on the matching process, sensitivity analyses were performed using different combinations of matching variables. Those analyses showed similar results to the ones here presented. The stratified analysis for gender showed only little variation across the strata for any data source, so that representativeness can be assumed [19].

After considering the limitations of the capture–recapture method applied to Dutch STD surveillance systems we conclude that this method cannot replace population surveys [9, 13], but that it may provide insight into the sensitivity of surveillance systems and, hence, is valuable in evaluating these systems. Nevertheless, before initiating any capture–recapture analysis the requirements for the data sources and their fulfilment need to be considered carefully to allow judgement of the applicability of the method [9, 10].

We found that the sensitivity estimates of syphilis and gonorrhoea were significantly different. This difference may have several reasons. Currently, syphilis is a rare disease with a strong psychological and sociological association which may influence the consultation and reporting behaviour of patients and medical professionals. Compared to gonorrhoea, syphilis is more clearly located within certain risk groups (e.g. drug users, prostitutes and their clients) who may contact health services more frequently [20, 21].

The use of the capture–recapture method may improve the interpretation of surveillance data. For the Netherlands, it follows that the actual incidence of both STD, but especially of gonorrhoea, seems to be much higher than observed in the crude surveillance data. This information is useful both for comparing data and for policy makers. The value of comparing international surveillance data is very limited if the sensitivity of the different systems is not known [22]. Regular measures of the sensitivity of relevant surveillance systems is an increasingly important area of information for international co-operation and the capture–recapture method may help to provide these data.

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REFERENCES

1. Centers of Disease Control. Guidelines for evaluating surveillance systems. MMWR 1988; **37** (suppl. no. S-5): 1–18.
2. Thacker SB, Choi K, Brachman PS. The surveillance of infectious diseases. JAMA 1983; **249**: 1181–5.
3. Laar MJW van de, Water HPA van de. Gonorrhoea and syphilis in the Amsterdam region. NIPG-TNO rapport, 1987.
4. Miltenburgh HMTM, Paalman MEM, Reus JTNM. Gonorrhoea in The Netherlands. Utrecht: SOA Stichting, 1988.
5. Robles SY, Marrett LD, Clarke AE, et al. An application of capture–recapture methods to the estimation of completeness of cancer registration. J Clin Epidemiol 1988; **41**: 495–501.
6. Sutter RW, Cochi SL, Brink EW, et al. Assessment of vital statistics and surveillance data for monitoring tetanus mortality, United States, 1979–1984. Am J Epidemiol 1990; **131**: 132–42.
7. Hubert B, Desenclos JC. Evaluation of the exhaustiveness and representativeness of a surveillance system using the capture–recapture method. Application to the surveillance of meningococcal infections in France in 1989 and 1990. Rev Epidem et Santé Publ 1993; **41**: 241–9.
8. Hook EB, Regal RR. The value of capture–recapture methods even for apparent exhaustive surveys. Am J Epidemiol 1992; **135**: 1060–7.
9. Desenclos JC, Hubert B. Limitations to the universal use of capture–recapture methods. Int J Epidemiol 1994; **23**: 1322–3.
10. Hook EB, Regal RR. Capture–recapture methods in epidemiology: methods and limitations. Epidemiol Rev 1995; **17**: 243–64.
11. Chapman DG. Some properties of the hypergeometric distribution with applications to zoological sample censuses. Univ Calif Public Stat 1995; **1**: 131–60.
12. Seber GAF. The effect of trap response on tag recapture estimates. Biometrics 1970; **26**: 13–22.
13. Papoz L, Balkau B, Lellouch J. Case counting in epidemiology: limitations of methods based on multiple data sources. Int J Epidemiol 1996; **25**: 474–8.
14. Wittes JT, Colton T, Sides VW. Capture–recapture methods for assessing the completeness of case ascertainment when using multiple information sources. J Chron Dis 1974; **27**: 25–36.
15. Fienberg SE. The multiple recapture census for closed populations and incomplete 2k contingency tables. Biometrika 1972; **59**: 591–603.
16. Stephen C. Capture–recapture methods in epidemiological studies. Infect Control Hosp Epidemiol 1996; **17**: 262–6.
17. Dutch STD Foundation. STD-registration at Municipal Health Services in 1993. Utrecht, 1994.
18. Jones JL, Meyer P, Garrison C, Kettinger L, Hermann P. Physician and infection control practitioner HIV/AIDS reporting characteristics. Am J Public-Health 1992; **82**: 889–91.
19. Sekar CC, Demin WE. On a method of estimating birth and death rates and the extent of registration. Amer Stat Ass J 1949; **44**: 100–15.
20. Zessen G van, Sandfort TGM. Seksualiteit in Nederland: seksueel gedrag, risiko en preventie van AIDS. Amsterdam, The Netherlands: Swets & Zeitlinger, 1991.
21. Johnson AM, Wadsworth J, Wellings K, Field J. Who goes to sexually transmitted disease clinics? Results from a national population survey. Genitourin Med 1996; **72**: 197–202.
22. Reintjes R, van de Laar MJW. STD surveillance, prevention and care in Europe. STD bulletin; Special Issue, June 1997: 4–9.