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ORIGINAL ARTICLE

Quality Assessment of Hospital Discharge Database for Routine Surveillance of Hip and Knee Arthroplasty–Related Infections

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OBJECTIVE. Surgical site infection (SSI) surveillance represents a key method of nosocomial infection control programs worldwide. However, most SSI surveillance systems are considered to be poorly cost effective regarding human and economic resources required for data collection and patient follow up. This study aims to assess the efficacy of using hospital discharge databases (HDDs) as a routine surveillance system for detecting hip or knee arthroplasty–related infections (HKAIs).

METHODS. A case-control study was conducted among patients hospitalized in the Centre region of France between 2008 and 2010. HKAI cases were extracted from the HDD with various algorithms based on the *International Classification of Diseases, Tenth Revision*, and procedure codes. The control subjects were patients with hip or knee arthroplasty (HKA) without infection selected at random from the HDD during the study period. The gold standard was medical chart review. Sensitivity (Se), specificity (Spe), positive predictive value (PPV), and negative predictive value (NPV) were calculated to evaluate the efficacy of the surveillance system.

RESULTS. Among 18,265 hospital stays for HKA, corresponding to 17,388 patients, medical reports were checked for 1,010 hospital stays (989 patients). We identified 530 cases in total (incidence rate, 1% [95% confidence interval (CI), 0.4%–1.6%), and 333 cases were detected by routine surveillance. As compared with 480 controls, Se was 98%, Spe was 71%, PPV was 63%, and NPV was 99%. Using a more specific case definition, based on a sample of 681 hospital stays, Se was 97%, Spe was 95%, PPV was 87%, and NPV was 98%.

CONCLUSIONS. This study demonstrates the potential of HDD as a tool for routine SSI surveillance after low-risk surgery, under conditions of having an appropriate algorithm for selecting infections.

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Surgical site infections (SSIs) are rare complications of hip and knee replacements but are devastating for the patient, because they may have serious medical consequences.[1-6] The resulting financial burden and the emotional component emphasized by the media in the general population have made these infections a key target for epidemiologic SSI surveillance.[7-11] However, most SSI surveillance systems are considered to be poorly cost effective because of the considerable human and other resources required for data collection and patient follow up.[2,12-14] Detection based on the combination of surveillance database linked with data extracted from hospital information systems could potentially provide a solution, decreasing the amount of missing data and increasing the sensitivity of SSI identification.[15-17]

In France, all discharges from the hospital are registered in the national hospital discharge database (HDD). The HDD is therefore a permanent medical administrative database suitable for epidemiologic studies, especially for bone and joint infections.[11,18-21] This study aims to assess the efficacy of using the HDD as a routine surveillance system for detecting hip or knee arthroplasty (HKA)–related infections (HKAIs).

METHODS

A case-control study was performed using data collected from the HDD between 2008 and 2010. Data for all patients undergoing primary HKA between January 2008 and December 2009 were extracted from the HDD of a French region (Région Centre, which includes 2.5 million inhabitants and 38 private and public hospitals). The French HDD is based on the mandatory notification of each hospital stay, through coded summary, for all French hospitals, public or private. The patients were selected on the basis of their having undergone a surgical HKA procedure, according to the French Common Classification of Medical Acts (FCCMA), and the corresponding specific code for prosthetic device (material code; Table 1).[11]

To obtain patient-based data, multiple hospitalizations in

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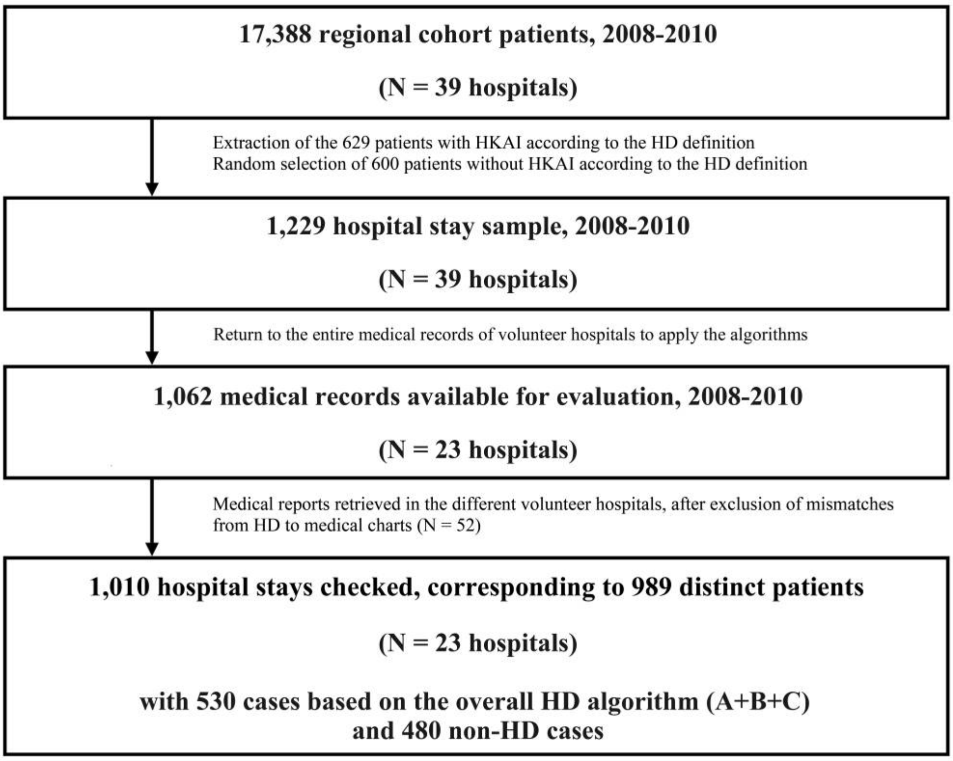
17,388 regional cohort patients, 2008-2010
(N = 39 hospitals)
Extraction of the 629 patients with HKAI according to the HD definition
Random selection of 600 patients without HKAI according to the HD definition
1,229 hospital stay sample, 2008-2010
(N = 39 hospitals)
Return to the entire medical records of volunteer hospitals to apply the algorithms
1,062 medical records available for evaluation, 2008-2010
(N = 23 hospitals)
Medical reports retrieved in the different volunteer hospitals, after exclusion of mismatches from HD to medical charts (N = 52)
1,010 hospital stays checked, corresponding to 989 distinct patients
(N = 23 hospitals)
with 530 cases based on the overall HD algorithm (A+B+C) and 480 non-HD cases

FIGURE 1. Extraction of the validation sample of hip or knee arthroplasty (HKA) using the algorithm based on hospital discharge (HD) codes. A total of 600 case patients and 600 control subjects were nested in the regional cohort, 2008–2010. For the HD algorithm (A+B+C), cases were defined as instances of HKA infection (HKAI) extracted from the HD database according to various algorithms using the *International Classification of Disease, Tenth Revision*, and procedure codes (see "Methods").

the HDD were linked via the unique encrypted patient identification number. All patients who underwent HKA in 2008–2009 were assessed by HDD control until the end of 2010, resulting in a minimum of 12 months' of patient follow-up. During this period, surveillance of HKAI occurrence was performed on the basis of an algorithm using the *International Classification of Diseases, Tenth Revision* (ICD-10), and FCCMA, with 3 levels of classification (Table 1).[11]

The diagnosis of HKAI was made according to an algorithm using HDD developed by various experts in prosthetic joint infections using widely accepted criteria,[22,23] including orthopedic surgeons, doctors specializing in infectious diseases or infection control (ICPs), and doctors specializing in medical information systems. HKAI case definition was based on the diagnosis and procedure codes used in the HDD summary, their position in the summary, and the presence of specific codes. Pediatric HKAI were excluded from analysis because of their very low number (13 primary HKA stays among 4 children) and very different clinical presentation and outcomes.[21]

The algorithm was designed to link 3 types of diagnosis code (representative HKA-related infection codes, orthopedic infection codes, and imprecise HKA complication codes) with FCCMA codes for the procedures performed to manage HKAI (including debridement, prosthesis removal, and exchange or implant revision). HKAI was considered when the HDD summary notified at least 1 ICD-10 diagnosis of HKAI or a specific surgical procedure. The various combinations were grouped together into 3 different categories. Algorithm A, indicating a high level of proof, was based on the association of 2 or more precise codes among representative HKA-related infection codes (infection and inflammatory reaction due to internal joint prosthesis: T84 codes) and/or orthopedic infection code (septic arthritis or osteomyelitis, infection codes: A or B codes) and/or an FCCMA procedure code. Algorithm B was the combination of an imprecise T code (unspecified complication of internal orthopedic prosthetic device) with an orthopedic infection code or a surgical procedure code. Algorithm C, indicating a lower proof level, corresponded to the presence of a single diagnosis code or FCCMA code.

For quality assessment of the routine system based on HDD algorithms, a medical chart review was performed in every hospital of the region and used as the gold standard. An infectious disease specialist/ICP, together with an orthopedic surgeon or doctor specializing in medical informatics, read the complete medical reports, including clinical data, microbiological assays, and radiographs and magnetic resonance imaging (MRI) with the radiologist's interpretation. The iden-

TABLE 1. Detection of Primary Knee or Hip Arthroplasty Infections That Occurred in Patients 15 Years of Age and Older at 39 Hospitals, Région Centre, France, 2008–2010

Metric	Method of detection
Global hospital stays: 1,000,000 hospital stays	Regional HDD, 2008–2009
Primary replacement of hip or knee: 18,253 hospital stays	FCCMA codes for hip replacement (NEKA010–NEKA021, NEMA018, NEMA020) and knee replacement (NFKA006–NFKA009, NFMA013) plus 1 specific code for prosthetic material (implant)
First joint replacement: 17,388 patients	Stratification by unique patient identification number (ANO)
First hip/knee infections: 629 stays/497 patients	Defined by the presence in the resume and their associations with ICD-10 codes or FCCMA codes, 2008–2010, for prosthetic joint–specific infection or inflammation (T845, T846, T847, Z76800); prosthetic joint unspecified complication (T813, T814, T818, T848, T849, Z470); prosthetic joint mechanical complication (T840–T844); infection codes, including septic arthritis (M000–M002, M008–M013, M016, M018, M130, M1315, M1316, M138, M1395, M1396); osteomyelitis (M860–M866, M868, M869, M900, M902); sepsis codes (A, B, R); and abscesses (L) plus or minus FCCMA specific surgical procedure codes for debridement, prosthesis removal, exchange, or implant revision

NOTE. FCCMA, French Common Classification of Medical Act; HDD, hospital discharge database; ICD-10, *International Classification of Diseases, Tenth Revision.*

tification of any infectious agent was also checked via the medical charts to validate HKAI.

For estimation of the reliability parameters of the surveillance system, a control group of patients with HKA without infection was randomly selected according to the HD algorithm from the HKA cohort. A sensitivity-specificity analysis was performed with 3 different algorithms, based on the following case definitions: cases selected with algorithm A alone, cases selected with algorithms A and B, and all selected cases (selected with algorithms A, B, and C). Sensitivity (Se), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV) were calculated with these different strategies, together with their 95% confidence intervals (CIs). Statistical analysis was performed with SAS software, version 9.1 (SAS).

RESULTS

The regional HDD for the 2-year period contained records for 1 million hospital stays, 18,253 of which (2%) met the case criteria for primary HKA. Ninety-nine percent of hospital discharges were correctly linked to the patient database, linking 17,388 patients with 832,399 adult hospital stays (Table 1).

During the 2008–2010 period, 629 hospital stays (3.5% of the cohort) met the HDD criteria for HKAI, corresponding to 497 cohort patients. Six hundred controls were then randomly selected. In total, 23 of the 38 hospitals in the region agreed to participate in the medical chart review, allowing 1,062 reports to be checked. The other 15 hospitals were smaller institutions, accounting for less than 200 of the 1,200 patients initially selected. Fifty-two medical charts were not retrieved or did not match any of the patients in the HDD. Finally, 1,010 hospital stays were included corresponding to 989 patients (Figure 1).

The reliability parameters for the 3 definitions of HKA-related infection are reported in Table 2. Overall, 530 cases were identified from the HDD, 333 of which were confirmed as true positive cases, the other 197 being false positives. By contrast, 480 (47.5%) of 1,010 charts were test negative; 474 of these were true negatives, the other 6 being false negatives. Se and NPV were high whatever definition was used (97% or greater), whereas PPV differed by 25% between definition A (87%) and definitions A, B, and C combined (72%). Agreement with the results of medical record review was highest for definition A, identified as the optimal strategy, with the highest PPV, Sp, Se, and NPV.

The overall incidence estimation of HKAI was at 1.8% (497 patients with prosthetic joint infection in the overall case definition [497 × 63%] among the 17,388 cohort patient with HKA). Based on the overall PPV, which was estimated at 63% (95% CI, 59.8%–65.8%), the extrapolated incidence of HKA-related infections would be estimated at between 1.7% and 1.9%. Based on case definition A, HKAI incidence would be estimated at 0.81% (163 patients with prosthetic joint infection according to case definition A, among the 17,388 cohort patients with HKA). According to the calculated PPV of 87% (95% CI, 84.5%–89.5%), the extrapolated incidence of HKA-related infections would be between 0.79% and 0.83%.

DISCUSSION

The reliability of HDD-based surveillance for SSI after low-risk surgery, such as HKA, was considered acceptable for routine monitoring, provided that SSI incidence is in the range previously reported in studies worldwide.[12,14,15,24,25] According to the reliability parameters commonly used to evaluate surveillance systems, this method can be considered highly sensitive and specific (greater than 95% Se and Sp)

TABLE 2. Estimation of Sensitivity, Specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) of the Different Case Definitions of Prosthetic Joint Infection Proposed ($n = 1{,}010$)

	No. (%) of cases		Percentage (95% CI)			
Sample validation	True positive	False positive	Sensitivity	Specificity	PPV	NPV
Definition A ($n = 681$)	174 (25.6)	27 (4.0)	97 (95.7–98.3)	95 (93.4–96.6)	87 (84.5–89.5)	98 (96.9–99.1)
Definition A and B ($n = 821$)	246 (30.0)	75 (9.1)	98 (97.0–99.0)	83 (80.4–85.6)	72 (68.9–75.1)	99 (98.3–99.7)
Definition A, B, and C ($n = 1{,}010$)	333 (33.0)	197 (19.5)	98 (97.1–98.9)	71 (67.8–73.4)	63 (59.8–65.8)	99 (98.1–99.5)

NOTE. Definition A was association of at least 2 codes for prosthetic joint infection. Definition B was association of 2 codes for less specific complication. Definition A, B, and C was overall selected codes. Based on a 1% incidence value for definition A, the PPV and NPV would be 16.4% and 99.7%, respectively, using Bayes formula. CI, confidence interval.

for the detection of HKAI on condition that the detection algorithm is validated. In addition to its ability to detect SSI, the HDD-based system could potentially reduce costs and the need for human resources. First, patient linkage enabled HDD to obtain exhaustive information from the HDD concerning all the hospital stays of the selected patients, with no need to contact the doctors or ICPs managing these patients. Second, this exhaustive database limited the amount of missing data and facilitated surveillance after hospital discharge, which is not currently routinely performed in SSI surveillance programs.[4,26] The HDD screening model validated here is thus a potentially reliable tool for assessing the quality of care in orthopedic surgery and could be used as a reference method for hospital benchmarking.

The efficacy of the HDD system differed significantly according to the case definition used, potentially resulting in false-positive results, whereas the false-negative rate remained relatively low, regardless of the definition used. The PPV reported here was higher than those reported by many other SSI studies. In another French study, the sensitivity and specificity of SSI detection were estimated at 18.4% and 100%, respectively, on the basis of surgeon notification and 26.3% and 99.5%, respectively, on the basis of discharge diagnosis codes.[15] For colorectal surgery, screening for SSI by the cross-referencing of databases had a PPV of 75% and a NPV of 85%.[27] An American study in which ICD-10 algorithms were used to detect HKAI reported similar Se, Spe, and NPV but a lower PPV (11%).[28] A Kenyan study reported an Se of 70% and an Spe of 100% for the detection of SSI after hospital discharge in this setting.[29] HDD-based surveillance is suitable for routine data collection for general purposes in hospitals and constitutes a useful alternative to most of the existing systems that are based on sequential surveys or limited periods of follow-up.[30] Improving performance of routine data collection has been increased by recent innovations in the field of medical information systems.[8,15,31,32] The existence of this exhaustive medical database provides French researchers with an extraordinary opportunity. The anonymous linkage method provides information about patient follow-up through consecutive hospital stays, which is particularly useful for epidemiological surveillance.[11,18,19] Other countries, in Scandinavia and North America in particular, have also made use of their medical information systems for public health purposes or research projects.[20,32,33] The potential of these systems, evaluated for precise objectives, makes them particularly useful.

This model has limitations, particularly as concerns the quality of the data coded. A recent public audit of surveillance systems in the United Kingdom showed that SSI rates may not be appropriate for benchmarking,[34] as considerable variation was observed in the data collected and in SSI reporting.[34,35] Unlike most European surveillance systems, HDD-based surveillance does not include NNIS components, such as surgery duration or American Society of Anesthesiologists score. However, the study focused on clean elective orthopedic surgery with patients belonging to NNIS 0 index category. The reliability of the coding system used in the HDD remains debatable, because data are coded by different healthcare professionals throughout France.[11,17,18,20] An American study showed that administrative coding, when used alone, is a poor tool for healthcare-associated infection surveillance, with a PPV of less than 60%.[33] However, given the delay involved, an HDD-based system is not appropriate for early detection and alerts in outbreak situations. Conversely, other recent studies using robust medical information systems together with surveillance network data have reported better results, with Se, Sp, and PPV of 95%, 99%, and 84%, respectively.[11,28] The case definition algorithm used here was constructed by a multidisciplinary team using different combinations of relevant codes for HKAI infections hospital stays. The robustness of the method was demonstrated by checking a large panel of medical reports in a wide range of hospitals (public and private sector, general and university hospitals, in rural and urban areas) with several case definition algorithms differing in the balance between Se and Sp. This approach controlled for differences in coding practice between doctors. The reliability parameters presented are approximate (not the entire cohort used for reliability assessments), but the use of different case definitions based on hospital discharge codes showed predictive values, Se, and Sp to be high.

Finally, HDD-based surveillance, despite its limitations, could be promoted as a cost-effective method for routine SSI surveillance and as an alternative to the usual surveillance systems, particularly in the context of low-risk surgery in France. Cost-benefit analysis and studies combining multiple hospital databases should now be performed. Readers may contact the authors for any additional information or questions about the algorithm framework.

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