General Surgery (2017) Volume 1, No 1 doi：10.18282/gs.v1i1.32

Original Research Article

How to use administrative data for surgical outcomes in acute diverticulitis

Michael K-Y Hong[1,2*], Anita R Skandarajah[1,2], Omar D Faiz[3], Ian P Hayes[1,2]

[1] Department of Surgery, The Royal Melbourne Hospital, The University of Melbourne, Parkville, Australia
[2] Department of General Surgical Specialties, Melbourne Health, Parkville, Australia
[3] Department of Surgery, Imperial College, London, United Kingdom
*Correspondence: mkyhong@gmail.com

***Abstract*:** The measurement of quality outcomes is crucial in surgical care. Administrative data are increasingly used but their ability to provide clinically useful information is reliant on how closely the coding can define a particular cohort. In acute admissions for diverticular disease, it is important to differentiate between complicated and uncomplicated diverticulitis, and between diverticulitis and diverticular bleeding. We aim to develop a method to define clinically relevant cohorts of patients from an administrative database in acute diverticulitis. Codes for acute diverticulitis were found from the ICD-10-AM (Australia and New Zealand) coding system, and the accuracy was established with retrospective chart review and cross-referenced with a clinical database at a single institution. Coding of non-diverticular and missed diverticular cases was examined to determine non-diverticular codes that could differentiate these cases. These were combined into logic algorithms designed to differentiate between uncomplicated and complicated diverticulitis admissions derived from an administrative database. Specific K57 diverticular codes possessed sensitivity and positive predictive values of 0.92 and 0.69 for uncomplicated diverticulitis, respectively, with 0.61 and 0.92 for complicated diverticulitis, respectively, based on 153 cases. Most of the missing cases were usually complicated diverticulitis whilst some cases coded incorrectly as uncomplicated diverticulitis were often found as undifferentiated abdominal pain. Diagnostic codes combined into algorithms that accounted for predictable variations improved cohort definition. In conclusion, algorithms with combined codes improved definitions of clinically relevant cohorts for acute diverticulitis from an Australian or New Zealand administrative database. This method may be used to develop logic algorithms for other surgical conditions and enable widespread measurement of relevant surgical outcomes.

***Keywords*:** Validation; administrative data; diverticulitis; coding; algorithm

Received: 13th Sep. 2017 **Accepted:** 18th Nov. 2017 **Online:** 24th Nov. 2017

Introduction

Hospitals routinely collect administrative data for every patient admission. Diagnoses and procedures are translated into alphanumeric codes according to national coding classification systems. With an ability to transcend hospital, state and international boundaries, this vast repository of data holds enormous potential for clinical outcomes research and surgical audit. Deriving meaningful disease-specific clinical outcomes relies on the understanding on how administrative codes correlate with, and differ from, clinical classifications of a disease[1,2].

Administrative codes are often used in a way that results in heterogeneous patient groups. Drawing clinically relevant conclusions from these data are difficult. The Victorian Audit of Surgical Mortality has recently used administrative data in an evaluation of their audit process; however, the disease-specific outcomes were not provided[3]. In studies on acute diverticulitis, the use of administrative coding often leads to inclusion of patients with diverticular bleeding despite being a different clinical entity[4-7]. Whilst studies using administrative data can provide outcomes for broad disease groups, information on specific clinical diagnoses are more valuable to surgeons.

Coding for diseases is prone to subjectivity, variability and error[8]. Its accuracy and completeness depend on the clarity of information presented by clinicians to coding staff, activity-based funding, administrative culture and available resources. However, when using administrative data to retrospectively measure surgical practice and outcomes, the choice of codes used for cohort definition is pivotal. A method to maximise the use of coding to define a cohort is needed.

Colonic diverticular disease has a broad spectrum of manifestations. We hypothesised that a method involving chart review, examination of coding, and determination of predictable variation would allow us to create logic algorithms that could improve the definition of clinically relevant cohorts from an administrative database for acute diverticulitis.

Materials and methods

A systematic approach to identify relevant codes and validate them with a clinical cohort was performed. The project was approved by the Human Research Ethics Committee, Office of Research, Melbourne Health.

Defining the clinical cohort

Despite multiple clinical classifications for acute diverticular disease, only three broad subgroups of diagnoses are relevant: uncomplicated diverticulitis, complicated diverticulitis, and diverticular bleeding. The specific subtypes of complicated diverticulitis include free perforation, localised perforation, abscess, and fistula or obstruction from stricture. We defined an episode of acute diverticulitis as a patient having computed tomography (CT) evidence of pericolic inflammation with diverticulosis, requiring emergency admission, and having consistent clinical features. These included abdominal pain and tenderness, without features of colitis such as bloody diarrhoea.

Selection of family of codes based on descriptors from coding system

The 5-character ICD-10-AM coding system used in Australia and New Zealand allows for more specific descriptions of the manifestations of diverticular disease than ICD-10 (England) or ICD-9-CM (USA). In this system, 24 codes with the K57 diverticular stem describe colonic diverticular disease (**Table 1**). No code labels include descriptions for diverticular fistula or stricture.

A list of patient episodes was generated using the K57 diverticular stem code as principal diagnosis, categorised as emergency admissions. This was retrieved from the Melbourne Health Data Warehouse, based at an adult metropolitan tertiary referral hospital, from the period of July 2012 to June 2013. This time period was chosen because one year worth of chart review was felt to be at the limits of practicality and of sufficient yield. It was also likely to contain the most accessible clinical information. Each episode included diagnostic and procedure coding. Readmissions were counted as separate episodes and included for clinical correlation of the coding.

Checking frequency of code used over time

The frequency of K57 codes used as a principal diagnostic code was charted to determine coding behaviour over eight years. This identified which of the 24 K57 colonic diverticular codes were being used.

Matching the codes with a clinical diagnosis

Based on the patient list from the administrative data, patient charts were retrospectively analysed by two colorectal surgeons, who were blinded to the codes. CT imaging was used as the diagnostic gold standard based on its good sensitivity (0.91–0.98)[9,10] and specificity (0.77–0.99)[11] for acute diverticulitis, and its ability to differentiate complicated from

Table 1. K57 diverticular coding from ICD-10-AM (Australia and New Zealand) with their code descriptors

K	5	7	0	0
Digestive tract	Intestine	Diverticular	0 small intestine with perforation 1 small intestine without perforation 2 large intestine with perforation 3 large intestine without perforation 4 small and large intestine with perforation 5 small and large intestine without perforation 8 unspecified intestine with perforation 9 unspecified intestine without perforation	0 diverticulosis with haemorrhage 1 diverticulosis with haemorrhage 2 diverticulitis without haemorrhage 3 diverticulitis with haemorrhage

Note: The fourth character determines perforation and the fifth determines inflammation and haemorrhage uncomplicated diverticulitis. For cases without CT imaging, clinical features were assessed to determine the most likely diagnosis. Rectal bleeding was only attributed to diverticular disease if there was supportive radiological or endoscopic evidence. Our final diagnosis was used as the reference standard to measure the accuracy of the diagnostic codes. A Cohen's κ coefficient was calculated to measure the inter-observer reliability of the final clinician diagnosis.

The accuracy of each code for its clinical correlation was then expressed as a proportion (positive predictive value, or PPV). The overall sensitivity and PPV of codes were calculated. The final 2 × 2 table was not completed until cases missed by coding were found and included to calculate specificity and negative predictive value (NPV).

Exploring unexpectedly useful codes

Some diagnostic codes were frequently used and possessed consistent clinical diagnoses, but had acquired code descriptors without clinical equivalent (such as diverticulosis with abscess). A chart review was undertaken for cases defined by these codes over eight years (2005–2013) to determine their utility. A broader study period was used for this purpose due to the rarity of some of these codes.

Searching for cases missed by the coding family descriptor

The audit system of the General Surgical department of this hospital was used as an independent clinical database. It contained every inpatient admission and referral under General Surgery. It was cross-referenced to retrieve cases that were not identified by the K57 diverticular stem code in the administrative database. All emergency cases related to diverticular disease were audited between July 2012 and June 2013. They were matched to the dataset created by the one-year chart review to detect cases missed by K57 coding. During the study period, it was hospital policy that a General Surgeon reviewed all cases of diverticulitis, which ensured the completeness of this database.

Study of coding of missed cases

The cases of acute diverticulitis missed by K57 coding were examined for other codes that may allow them to be included in a cohort defined by coding. Further chart review was undertaken for cases defined by these other codes to evaluate their discriminatory ability. Due to the relative rarity of these codes, the dataset was examined over an eight-year period (2005–2013).

Combining useful codes into logic algorithms

By studying numerous codes associated with acute diverticulitis, we developed algorithms to enable a more accurate retrieval of admissions from an administrative database. These algorithms were based on coding combinations that reflected all possible coding behaviour for each particular subtype of complicated diverticulitis (summarised in **Figure S1**).

Results

Definition of clinical cohort

Acute diverticulitis was studied in two cohorts: uncomplicated and complicated diverticulitis.

Selection of family of codes based on descriptors from coding system

Using all K57 codes from ICD-10-AM (Australia and New Zealand), 836 patient episodes were found between July 2005 and June 2013. After exclusion of 3 cases of small bowel diverticular disease, 153 episodes occurred between July 2012 and June 2013, and these were subjected to chart review.

Frequency of code used over time

Over eight years, the most common code used was K5732 (diverticulitis without perforation, abscess or haemorrhage).

Some codes without acute clinical correlation, including K5720 (diverticulosis of large intestine with perforation and abscess without haemorrhage) and K5730 (diverticulosis), were used more frequently than anticipated. Whilst diverticulosis without inflammation is a pathological entity, it is asymptomatic and therefore unlikely to be the cause of an emergency admission. The use of each diverticular code was consistent across the eight years including certain codes that were rarely or never used (Figure S2).

Codes matched with a clinical diagnosis

The charts from 153 patient episodes derived from the administrative data were reviewed and a final clinical diagnosis was assigned. The clinician inter-observer agreement for the final diagnosis was excellent with Cohen's κ of 0.85. Most of the discrepancies were in distinguishing diverticular bleeding from other causes of per rectal bleeding.

The chart review identified 66 cases of uncomplicated diverticulitis, whereas administrative coding overestimated this with 88 cases (K5732 and K5792). The discrepancy was due to the inclusion of 'abdominal pain' and incorrectly coded cases of complicated diverticulitis.

Whilst coding defined 24 cases of complicated diverticulitis (K5722), there were 32 clinical cases in total. Clinically, most of the cases were localised perforation (15 cases) or abscess (11 cases). Free perforation (4 cases), fistula (1 case), and stricture (1 case) were less common. Meanwhile, coding overestimated the number of probable diverticular bleeding admissions. The diagnostic uncertainty in cases of diverticular bleeding led to a PPV of 0.57 for the K5731 and K5791 codes. Diverticular bleeding is often clinically indistinguishable from other causes of rectal bleeding, and its management is similar. Therefore, defining this cohort individually from an administrative database has limited value and no attempt was made to create an algorithm for this condition.

Unexpectedly useful codes

K5720 (diverticulosis with perforation and abscess), a code without clinical meaning, had been used to code two cases of complicated diverticulitis in the study period of one year. A total of 21 cases of complicated diverticulitis were found from 24 instances of K5720 coding over the eight years using chart review.

Cases missed by the coding family descriptor

A review of the clinical database found that K57 coding accounted for 98 out of 102 cases (0.96). This enabled a true calculation of sensitivity and PPV of the codes for their clinical descriptor (**Table 2**). Specificity and negative predictive value (NPV) were above 0.99 for uncomplicated and complicated diverticulitis. These were calculated based on the number of patients admitted at the emergency department in that particular year (n = 25409).

Three diverticular fistulae and one diverticular stricture causing large bowel obstruction were missed by coding. A diverticular colovesical fistula was coded with N321 (vesico-intestinal fistula) but had no associated K57 code. Other miscoded colovesical fistula and stricture cases lacked any distinct coding to allow retrieval from an administrative database. In addition, a colovaginal fistula was coded with N824 (other female intestinal-genital tract fistula) and a secondary K57 (diverticular) code.

Coding of missed cases

N321 (vesico-intestinal fistula) was used for nearly all cases of diverticular colovesical fistulae. It was often listed as the principal diagnostic code, with or without a secondary K57 diverticular code. Finding cases by using N321 as a principal diagnostic code without any K57 code requires active exclusion of cancer and inflammatory bowel disorder cases to avoid inadvertent inclusion of non-diverticular fistulae. Similarly, cases of diverticular colovaginal fistulae could be found using N823 or N824 as principal diagnoses with a secondary K57 code, or as secondary codes to a principal K57 code.

Clinically significant diverticular stricture causing large bowel obstruction could only be distinguished by combining K566 (obstruction code), K57 (diverticular code), and a procedure code such as Hartmann's procedure, anterior resection, or total colectomy.

Table 2. Accuracy of K57 Coding for Final Diagnosis

Final Diagnosis	ICD-10-AM Codes	Number Coded	Correctly Coded	Sensitivity of Coding	PPV of Coding
Uncomplicated Diverticulitis (Total 66)	K57.32	70	0.71	0.92	0.69
	K57.92	18	0.61		
Complicated Diverticulitis (Total 36)*	K57.22	24	0.92	0.61	0.92
Diverticular Bleeding (Total 14)	K57.31	15	0.67	0.93	0.57
	K57.91	8	0.38		
Codes with No Clinical Correlate	K57.20, K57.30, K57.33, K57.90, K57.93	18	0	N/A	N/A

* Total number in final diagnosis group after missed cases were included

Development of logic algorithms

Fistula and stricture codes outside of the K57 diverticular group were incorporated into logic algorithms that could find cases of complicated diverticulitis that would otherwise be missed from an administrative dataset. 'Flagging' (database method of highlighting admission episodes) these cases and excluding them from a cohort of uncomplicated diverticulitis admissions would remove inadvertent cases of fistula or stricture (**Figure S3**)**.** When these algorithms were applied to the local cohort from July 2012 to June 2013, sensitivity of coding for complicated diverticulitis improved from 0.61 to 0.72.

Discussion

Clinically relevant cohorts of acute uncomplicated and complicated diverticulitis were defined from an Australian administrative database using logic algorithms. These were developed only after determining the appropriate codes to study, chart review for validation, comparison with an independent clinical database, and the study of how missed cases were coded. K57 coding for complicated diverticulitis suffers from low sensitivity due to missed cases of diverticular fistula. Variation exists in the coding of diverticular fistula cases, but this is predictable. Therefore, incorporation of fistula codes into algorithms could increase the ability of coding to find cases of complicated diverticulitis.

Administrative databases can generate huge patient numbers for individual or unit audit, comparative studies, hospital benchmarking, and policy-making[12]. Therefore, the correlation of these data with their clinical condition is vital to surgeons, administrators, and policy makers[13]. Our study demonstrates that using combinations of codes in algorithms may lead to a more clinically relevant cohort than using single principal diagnostic codes to define a cohort of patients.

Several studies on coding provide accuracy measures without trying to improve their use[14,15]. We have demonstrated through the development of logic algorithms that the accuracy and yield of administrative coding for some particular manifestations of a disease can be improved. An approach to explore the use of coding in providing meaningful clinical outcomes is proposed in **Box 1**.

When there are differences between coding and clinical terminology, the variations in coding may be predictable. This is particularly the case with complicated diverticulitis. The K57 code descriptors do not mention fistula or stricture. In cases of diverticular fistula or stricture, there may not be perforation, abscess or acute inflammation. A coder may therefore code these with K5730 (diverticulosis without perforation, abscess or haemorrhage). A fistula code in this circumstance would be listed as either the principal diagnosis or the secondary diagnosis, which our algorithms account for. Another example is the case of diverticular perforation, whereby diverticulitis is not mentioned at all. This is likely to be coded as K5720 (diverticulosis with perforation or abscess, without haemorrhage).

Our disease-specific understanding of coding can be used to create logic algorithms for international coding systems for acute diverticulitis, based on predicting coding variations. For example, ICD-10 (England) uses a 4-character coding where K573 (diverticular disease of colon) represents a mixed cohort comprising uncomplicated diverticulitis and diverticular bleeding. Coders may attempt to differentiate the diagnoses by applying secondary codes associated with bleeding, and this cohort can possibly be split based on these proposed secondary codes (**Figure S4**). Similarly, ICD-9-CM (USA) uses a single code of 562.11 to represent diverticulitis. Coders are likely to code secondary complication codes to differentiate complicated from uncomplicated diverticulitis. An algorithm can be designed to account for this (**Figure S5**).

Other attempts have been made to use algorithms of coding to increase the yield from an administrative database[16,17]. These include a validation study of a case- finding algorithm based on ICD-9 and ICD-10 codes for intussusception in the paediatric population in Canada in 2013[18]. Various combinations of codes from an administrative database were tested against a cohort defined by the chart review. A similar study was also performed for inflammatory bowel disease in an adult population[19]. Development and testing of these case- finding algorithms were purely statistical and focused on disease incidence. They were dependent on clinical practices that may be unique to the region, and therefore require regional validation. These algorithms are appropriate for epidemiological studies, but are limited when studying the disease-specific outcomes.

The main limitation of this study is that it is based on coding at a single institution. Algorithms were created to overcome variation in coding observed in this institution, but other coding combinations were included in anticipation of wider coding variation. Although application of the algorithms showed modest improvement over single codes in one year, these algorithms have been applied to a larger regional administrative dataset with demonstration of utility and derivation of clinically useful outcomes[20].

As coding standards exist and financial incentive is a key driver of coding, we feel that our methods are applicable to countries where activity-based funding exists. In the state of Victoria, Australia, activity-based funding has existed since 1993, but was only applied across Australia from 2011 onwards. Trained coders apply coding to admissions after discharge, and this process is subjected to periodic audit to ensure accuracy and therefore monetary yield. Knowledge of such processes is required in order to work with administrative data at an international level. In countries without financial incentives for coding development, multiple-coded episodes are unlikely to exist and such algorithms may have no value.

Box 1. Approach on the use of coding in providing meaningful clinical outcomes:

1. Define clinical cohort
2. Select family of codes based on descriptors from coding system
3. Check frequency of code use over time
4. Match the codes with a clinical diagnosis
5. Explore unexpectedly useful codes
6. Search for cases missed by the coding family descriptor
7. Study coding of missed cases
8. Combine useful codes into logic algorithms

Conclusion

Logic algorithms can be developed to define clinically relevant cohorts of acute diverticulitis admissions from an administrative database based on ICD-10-AM (Australian and New Zealand). We have demonstrated a much better disease-specific approach in terms of the administrative data usage in surgical research and audit. Our methodology for creating algorithms to identify meaningful cohorts from an administrative database can be extrapolated to other diseases.

Author contributions

Hong MKY and Hayes IP were involved in study conception, data collection, data analysis and manuscript writing. Skandarajah AR and Faiz OD were involved in conception, data analysis and editing of the manuscript.

Acknowledgements

We thank Andrew Tomlin, a statistician from Melbourne EpiCentre, University of Melbourne and Melbourne Health, for his assistance in data extraction from the Data Warehouse. An honour of appreciation also goes to Prof Kate Leslie for her suggestions in the manuscript preparation. We thank the members of GI Goal Group from Dr Foster Global Comparators (GC) Project at Dr Foster Ltd., in association with the Dr Foster Unit at Imperial College London, for their support of this project. This project was made possible by the Elizabeth & Vernon Puzey Scholarship, University of Melbourne.

Conflict of interest

The authors declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

Supplementary information

Figure S1. Development of logic algorithms for diverticulitis
Figure S2. Graph of relative frequency of K57 codes used in a single hospital over 8 years
Figure S3. Logic algorithms for acute diverticulitis in ICD-10-AM
Figure S4. Logic algorithms for ICD-10 (England)
Figure S5. Logic algorithms for ICD-9-CM (USA)
The supplementary information is available free of charge on GS's website.

Reference

1. Benchimol EI, Manuel DG, To T, Griffiths AM, Rabeneck L, *et al*. Development and use of reporting guidelines for assessing the quality of validation studies of health administrative data. J Clin Epidemiol 2011; 64(8): 821–829. doi: 10.1016/j.jclinepi.2010.10.006.
2. De Coster C, Quan H, Finlayson A, Gao M, Halfon P, *et al*. Identifying priorities in methodological research using ICD-9-CM and ICD-10 administrative data: Report from an international consortium. BMC Health Serv Res 2006; 6: 77. doi: 10.1186/1472-6963-6-77.
3. Beiles CB, Retegan C, Maddern GJ. Victorian Audit of Surgical Mortality is associated with improved clinical outcomes. ANZ J Surg 2015; 85(11): 803–807. doi: 10.1111/ans.12787.
4. Paterson HM, Arnott ID, Nicholls RJ, Clark D, Bauer J, *et al*. Diverticular disease in Scotland: 2000–2010. Colorectal Dis 2015; 17(4): 329–334. doi: 10.1111/codi.12811.
5. Vather R, Broad JB, Jaung R, Robertson J, Bissett IP. Demographics and trends in the acute presentation of diverticular disease: A national study. ANZ J Surg 2015; 85(10): 744–748. doi: 10.1111/ans.13147.
6. Razik R, Chong CA, Nguyen GC. Younger age and prognosis in diverticulitis: A nationwide retrospective cohort study. Can J Gastroenterol 2013; 27(2): 95–98. doi: 10.1155/2013/341501.
7. Mills AM, Holena DN, Kallan MJ, Carr BG, Reinke CE, *et al*. Effect of insurance status on patients admitted for acute diverticulitis. Colorectal Dis 2013; 15(5): 613–620. doi: 10.1111/codi.12066.
8. Nouraei SAR, Hudovsky A, Frampton AE, Mufti U, White NB, *et al*. A study of clinical coding accuracy in surgery: Implications for the use of administrative big data for outcomes management. Ann Surg 2015; 261(6): 1096–1107. doi:10.1097/SLA.0000000000000851.
9. Liljegren G, Chabok A, Wickbom M, Smedh K, Nilsson K. Acute colonic diverticulitis: A systematic review of diagnostic accuracy. Colorectal Dis 2007; 9(6): 480–488. doi: 10.1111/j.1463-1318.2007.01238.x.
10. Ambrosetti P, Jenny A, Becker C, Terrier TF, Morel P. Acute left colonic diverticulitis-compared performance of computed tomography and water-soluble contrast enema: Prospective evaluation of 420 patients. Dis Colon Rectum 2000; 43(10): 1363–1367. doi: 10.1007/BF02236631.
11. Laméris W, van Randen A, Bipat S, Bossuyt PMM, Boermeester MA, *et al*. Graded compression ultrasonography and computed tomography in acute colonic diverticulitis: Meta-analysis of test accuracy. Eur Radiol 2008; 18(11): 2498–2511. doi: 10.1007/s00330-008-1018-6.
12. Bottle A, Middleton S, Kalkman CJ, Livingston EH, Aylin P. Global comparators project: International comparison of hospital outcomes using administrative data. Health Serv Res 2013; 48(6 Pt 1): 2081–2100. doi: 10.1111/1475-6773.12074.

13. van Walraven C, Bennett C, Forster AJ. Administrative database research infrequently used validated diagnostic or procedural codes. J Clin Epidemiol 2011; 64(10): 1054–1059. doi: 10.1016/j.jclinepi.2011.01.001.
14. Drahos J, Vanwormer JJ, Greenlee RT, Landgren O, Koshiol J. Accuracy of ICD-9-CM codes in identifying infections of pneumonia and herpes simplex virus in administrative data. Ann Epidemiol 2013; 23(5): 291– 293. doi: 10.1016/j.annepidem.2013.02.005.
15. Erichsen R, Strate L, Sørensen HT, Baron JA. Positive predictive values of the International Classification of Disease, 10th edition diagnoses codes for diverticular disease in the Danish National Registry of Patients. Clin Exp Gastroenterol 2010; 3: 139–142. doi: 10.2147/CEG.S13293.
16. Lisi AJ, Burgo-Black AL, Kawecki T, Brandt CA, Goulet JL. Use of department of veterans affairs administrative data to identify veterans with acute low back pain: A pilot study. Spine (Phila Pa 1976) 2014; 39(14): 1151−1156. doi: 10.1097/ BRS.0000000000000350.
17. Nosyk B, Colley G, Yip B, Chan K, Heath K, *et al*. Application and validation of case-finding algorithms for identifying individuals with human immunodeficiency virus from administrative data in British Columbia, Canada. PloS One 2013; 8(1): e54416. doi: 10.1371/journal.pone.0054416.
18. Ducharme R, Benchimol EI, Deeks SL, Hawken S, Fergusson DA, *et al*. Validation of diagnostic codes for intussusception and quantification of childhood intussusception incidence in Ontario, Canada: A population-based study. J Pediatr 2013; 163(4): 1073–1079.e3.
19. Benchimol EL, Guttmann A, Mack DR, Nguyen GC, Marshall JK, *et al*. Validation of international algorithms to identify adults with inflammatory bowel disease in health administrative data from Ontario, Canada. J Clin Epidemiol 2014; 67(8): 887–896. doi: 10.1016/j.jclinepi.2014.02.019.
20. Hong MKY, Tomlin AM, Hayes IP, Skandarajah AR. Operative intervention rates for acute diverticulitis: A multicentre state-wide study. ANZ J Surg 2015; 85(10): 734–738. doi: 10.1111/ans.13126.