Published in final edited form as:

Am J Surg. 2012 September ; 204(3): 315–320. doi:10.1016/j.amjsurg.2011.10.023.

Secular Trends in Small Bowel Obstruction and Adhesiolysis in the United States, 1988–2007

Frank I. Scott, MD¹, Mark T. Osterman, MD, MSCE¹, Najjia N. Mahmoud, MD², and James D. Lewis, MD, MSCE^{1,3,4}

¹Department of Medicine, University of Pennsylvania, Perelman School of Medicine, Philadelphia, Pennsylvania

²Department of Surgery, University of Pennsylvania, Perelman School of Medicine, Philadelphia, Pennsylvania

³Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania, Perelman School of Medicine, Philadelphia, Pennsylvania

⁴Department of Biostatistics and Epidemiology, University of Pennsylvania, Perelman School of Medicine, Philadelphia, Pennsylvania

Abstract

Background—Post-operative adhesions are common following surgery and can cause small bowel obstruction (SBO) and require adhesiolysis. The impact that laparoscopy and other surgical advances have had on rates of SBO and adhesiolysis remains controversial. This study examines trends in discharges from US hospitals for SBO and adhesiolysis from 1988–2007.

Methods—We performed an analysis of secular trends for SBO and adhesiolysis, utilizing the National Hospital Discharge Survey (NHDS). Spearman correlation coefficients were calculated to assess trends over time.

Results—Rates of SBO were stable over time ($\rho=0.140$, $p=0.28$). Adhesiolysis rates were stable over time ($\rho=-0.18$, $p=0.17$, though there were significant downward trends in those >65 ($\rho=-0.55$, $p=0.01$) and 15–44 ($\rho=-0.84$, $p<0.01$).

Conclusions—There has been no significant change in overall rates of SBO or adhesiolysis from 1988–2007. For adhesiolysis, there were decreasing trends when stratified by age. Further research is required to understand the factors associated with adhesion-related complications.

Keywords

Adhesions; small bowel obstruction; adhesiolysis; secular trends

Introduction

Adhesions are fibrous connections that develop in response to trauma or surgical interventions involving the intra-peritoneal cavity. These fibrous bands are thought to occur in up to 93% of patients undergoing an intra-abdominal surgical procedure¹⁻⁴. Adhesion formation can result in significant morbidity and mortality, including small bowel obstruction (SBO) and infertility in women⁴⁻⁶. Adhesion-related complications are also responsible for up to 74% cases of SBO in adults⁷ and 30% of re-admissions at 4 years after an incident intra-abdominal surgery⁸. Such complications constitute a substantial amount of healthcare spending⁹⁻¹¹. The incidence of small bowel obstruction and other adhesion-related complications is thought to vary significantly with surgery type, with surgery involving the small or large bowel resulting in higher rates of this complication compared to those involving the foregut¹².

In recent decades, there has been a dramatic increase in laparoscopic intra-abdominal surgery. However, it is unknown whether this has translated into fewer post-operative complications due to adhesions. A 2004 review of 11 experimental studies involving animal models and 4 studies involving humans described decreased rates of adhesion formation after laparoscopy, but there was significant heterogeneity among the human studies¹³. Furthermore, some evidence suggests that this decrease in adhesion formation has not necessarily translated to a decrease in adhesion-related obstruction. For example, in a recent randomized, multicenter trial comparing outcomes in laparoscopic versus conventional approaches in colorectal surgery for malignancy, there was no difference between the two groups in obstruction-related complications at 3 years of follow-up¹⁴.

In addition to the growing use of laparoscopy, there have been multiple barrier agents introduced to prevent adhesions. These agents include physical barriers such as hyaluronic acid and carboxymethylcellulose (Seprafilm), oxidized regenerated cellulose (Interceed), expanded polytetrafluoroethylene (Preclude), and topical gels such as SprayGel. While these agents appear to decrease adhesions overall, there is conflicting evidence with regards to their efficacy in decreasing the rate of SBO over time¹⁵⁻¹⁷, and as such their utilization has been limited.

The impact that increasing use of laparoscopic methods and barrier agents have had on rates of obstruction and adhesiolysis in routine clinical practice remains unexplored. If laparoscopy or barrier agents are effective in reducing rates of adhesion formation, one would expect a decreasing rate of bowel obstruction and adhesiolysis as these surgical techniques becomes more common. Therefore, in this study we examined rates of discharges from US hospitals for small bowel obstruction and adhesiolysis from 1988 to 2007, utilizing population-based data from the National Hospital Discharge Survey (NHDS).

Methods

Data source

The NHDS, which has been conducted since 1965, abstracts medical and demographic information such as sex, age, race, marital status, length of stay, up to 7 diagnosis codes and 4 procedural codes, hospital region, and payor data from non-federal, short-stay hospitals in the United States¹⁸. There were 5,983 to 8,017 hospitals meeting the eligibility criteria to participate in the NHDS during the study period. From these, the NHDS samples approximately 500 to 550 hospitals each year, and approximately 450 hospitals respond to survey requests. Initially, NHDS data were recorded manually onto pre-defined data collection sheets by National Center for Health Statistics staff, U.S. Bureau of the Census staff, and local hospital employees. Since 1985, some hospitals have used computer-based

data collection. The method of data collection is not recorded in the final dataset. The primary sampling unit is considered to be geographic area, and hospitals are selected within each primary sampling unit, with probabilities proportional to their annual number of discharges.

NHDS data are collected in a stratified, multi-stage probability design, utilizing a three-stage sampling plan which was implemented in 1988, making comparisons between data collected from 1965–1987 and after 1987 difficult to interpret, as trends may be due to modified sampling procedures as opposed to actual changes in rates. As such, this study only used data from 1988 to 2007.

Diagnosis and procedure codes are recorded in the NHDS data utilizing the International Classification of Diseases, 9th revision, Clinical Modification (ICD-9 CM). Application of sampling weights allow for extrapolation to U.S. population-based estimates of rates of hospitalization for a given diagnosis for each year¹⁸.

Inclusion Criteria

Hospital discharges for individuals >15 years old were selected via appropriate diagnostic and procedural codes for SBO and adhesiolysis. We excluded children under age 15 as the etiology of SBO in children are often different from that in adults, while also allowing us to conform to the pre-defined methods for assessing standard error and relative standard error of the survey data, using constants provided with the dataset¹⁸. These constants are available for age-groups pre-determined by the NHDS: 15–44, 45–64, and 65 and over.

ICD-9CM codes 560.81, 560.89, and 560.9 were used to identify SBO. These same ICD-9CM codes were used during the entire study period for these diagnoses. For adhesiolysis, ICD-9CM codes 54.51 (Laparoscopic lysis of peritoneal adhesions) and 54.59 (Other lysis of peritoneal adhesions) were selected. Of note, prior to 1996, the code for adhesiolysis was 54.5, with the change likely representing increased use of laparoscopic techniques. As such this code was used in years 1987–1996. For both SBO and adhesiolysis codes, our primary analysis looked at the presence of one of these codes at any diagnostic code (1 through 7) or procedural code (1 through 4) position. As a secondary analysis, we assessed for the presence of these codes in only the first diagnostic or procedure code position, as this would most likely represent the primary reason for admission.

Because post-operative complications only occur in patients with prior surgery, we also examined trends in intra-abdominal operations over the same time period. We used 366 ICD-9CM codes to identify any intra-abdominal surgery other than adhesiolysis (APPENDIX I). As some surgeries may be performed as outpatient procedures, we also examined trends for partial or total colectomy as these surgical procedures are typically associated with admission.

The association of adhesiolysis at the time of another intra-abdominal surgery was also assessed. To perform this analysis, we looked at discharges with both an ICD-9CM code for an intra-abdominal surgery as well as a code for adhesiolysis as described above. We also calculated those adhesiolysis procedures not associated with intra-abdominal surgery via subtracting the associated group from the total adhesiolysis.

Statistical Analysis

All statistical analyses were conducted in 3 age groups: 15–44, 45–64, and >65 years old, allowing for exclusion of children while allowing for calculation of relative standard errors utilizing constants provided by the NHDS. Stata version 11.1 was used to convert all data into total discharges for each diagnostic code for SBO or adhesiolysis, using data

dictionaries and templates developed via the Interuniversity Consortium for Political and Social Research¹⁹. Using provided values and equations in the NHDS documentation, Relative Standard Errors (RSEs) were calculated¹⁸. Per recommendations of the NHDS, any estimates with a sample size <30 or RSE >30% should not be reported due to instability in the weighted estimates. All diagnostic codes for small bowel obstruction and adhesiolysis met these criteria for each year in the study. Rates per US population were then calculated using US census data for each year in the appropriate age category.

Spearman's correlation coefficient was used to assess for secular trends over time in the rates of hospitalization for SBO and adhesiolysis. Similarly correlation coefficients were calculated for each individual diagnostic code by survey year to assess for trends in each small bowel obstruction diagnostic code. The same procedure could not be performed for adhesiolysis due to the splitting of the primary code 54.5 to 54.59 and 54.51 in 1996. Similar methods were used to calculate correlation coefficients for total abdominal surgeries, colectomy, and adhesiolysis performed with and without an associated abdominal surgical code.

Results

After application of year-specific weights, there was an estimated total of 5,434,268 discharges for any diagnostic code for SBO during the study period, and annual rates ranged from 579 to 654 per 100,000 population. Annual rates for SBO varied by age category, ranging from 28.9 to 41.6 per 100,000 among those ages 15–44, from 120.8 to 155.8 per 100,000 among those ages 45–64, and from 402.5 to 480.6 per 100,000 among those age 65 or older (FIGURE 1). From 1988 to 2007, there was no significant trend in hospitalization rates for SBOs (Spearman's $\rho = 0.140$, $p = 0.28$). When stratified by age group, there was a significant increase in hospitalizations for SBO in the 15–44 age group (Spearman's $\rho = 0.70$, $p < 0.01$) (TABLE 1). Using only the most specific code for adhesion-related SBO, 560.81, there were a total of 1,602,613 discharges over the study period with similarly stable rates over the course of the study period ($p > 0.1$ overall and within each age group). When assessing for the presence of a diagnostic code for SBO as the primary diagnosis (i.e. in the first diagnostic code position), there was no significant trend for any of the codes assessed (data not shown).

With regards to trends in adhesiolysis, a total of 6,453,643 procedures were coded during the study period after extraction and application of population weights, and total annual rates ranged from 485.3 to 595.9 per 100,000. As seen with SBO, annual rates for adhesiolysis also varied by age category, and ranged from 95.3 to 142.1 per 100,000 for those 15–44, 138.4 to 171.2 for those 45–64, and from 229.0 to 307.2 per 100,000 for those older than 65 (FIGURE 2). There was a decreasing trend in annual rates of adhesiolysis, but this trend was not statistically significant (Spearman's $\rho = -0.18$, $p = 0.17$). When stratified by age category, there was a significant downward trend in both the >65 age group ($\rho = -0.55$, $p = 0.01$) and 15–44 age group ($\rho = -0.84$, $p < 0.01$), although the absolute magnitude of change was small. Given changes in coding that occurred in 1996, individual codes were not assessed. When assessing for the presence of an adhesiolysis code as the first procedural code, there was also no significant trend (data not shown).

Because post-operative complications only occur in patients with prior surgery, we also examined trends in intra-abdominal operations over the same time period. These data demonstrated decreasing rates of in-patient intra-abdominal surgery from 1988 to 2007 overall ($\rho = -0.29$, $p = 0.03$), with significant decreasing trends in all three age groups as well (TABLE I). However, overall rates of colectomy were stable over the study period ($\rho = -0.02$, $p = 0.83$).

We also assessed the proportion of adhesiolysis procedures that were associated with another intra-abdominal surgery. The majority of adhesiolysis procedures were associated with another intra-abdominal surgery, ranging from 75 to 88% of all adhesiolysis performed. There was no significant trend in adhesiolysis performed in the setting of another surgery overall ($p = -0.22$, $p = 0.09$), although there was a decreasing trend in adhesiolysis with another surgery in those 15–44 ($p = -0.88$, $p < 0.01$) and those >65 ($p = -0.65$, $p < 0.01$). Rates of adhesiolysis without an associated abdominal surgery ranged from 76.1 to 122 per 100,000 population. There was no significant trend in the overall population during the study period ($p = 0.16$, $p = 0.22$), though there did appear to be an increasing rate among those 15–44 and those 45–64 (TABLE 1).

Discussion

Small bowel obstruction due to adhesions remains a common complication of intra-abdominal surgeries. Our study demonstrates that in the United States there are between 224,015 and 344,080 hospitalizations for SBO and between 290,840 and 348,662 hospitalizations with performance of adhesiolysis surgery in people age 15 or older each year. Equally as important, despite advances in surgical techniques, there was no significant decline in these rates over a twenty-year period. The majority of these adhesiolysis procedures were associated with another intra-abdominal surgery.

It is currently debated what impact recent advances in surgical methods may have on the rates of adhesion-related complications. With the increasing popularity and application of laparoscopic surgical techniques in the 1990s and 2000s, one would expect that the rates of this complication should be decreasing over time if laparoscopic methods cause fewer adhesions and fewer SBOs. Yet we observed that rates of hospitalization for SBO and adhesiolysis were stable over the 20-year study period. This would suggest that while laparoscopic techniques are becoming more commonplace, they have not had a significant impact on the rates of SBO over time.

In addition to increasing utilization of laparoscopy, the development and application of barrier methods could also decrease rates of SBO and need for adhesiolysis. Such agents include oxidized regenerated cellulose (Interceed), Gore-tex, Fibrin film, and modified hyaluronate and carboxymethylcellulose (Seprafilm). While these agents do appear to decrease rates of adhesion formation, their efficacy in reducing adhesion-related complications has remained controversial^{20, 21}. Our data support the hypothesis that these methods have not had marked impact on SBO rates. We examined rates of use of these agents in the NHDS data and as expected there appeared to be increasing use among all but our oldest age group. However, the data had high RSEs and are therefore not presented so as to be consistent with NHDS reporting guidelines. Larger studies are needed to more accurately assess trends in use of these agents.

Interestingly, while overall rates of adhesiolysis remained stable from 1988 to 2007, this procedure did appear to be decreasing over time in those over 65 years of age and those between 15 and 45 once stratified by age. It is important to note that, while the correlation in these age groups is statistically significant, the absolute magnitude of change has been small. While the majority of adhesiolysis was performed in conjunction with another surgical procedure, these decreasing rates of adhesiolysis may represent a change in current philosophy in the management of adhesive-related complications, as more surgeons are comfortable providing supportive care for these patients, utilizing parenteral nutrition and serial imaging as opposed to operative intervention. It is also interesting to note that the rates of adhesiolysis without an associated intra-abdominal procedure were increasing in those

15–44 and those 45–64, though the rates of these procedures were much lower than adhesiolysis with an associated intra-abdominal procedure.

There are several possible interpretations of this study. It is possible that laparoscopy may have no effect on rates of SBO due to adhesions. This is consistent with the results of prior research demonstrating rates of obstructive complications that were similar in those who underwent laparoscopically assisted colectomy versus open colectomy, although the overall event rate of SBO in this study was low¹⁴. It may also be possible that the overall increased use of laparoscopy may have occurred too late in the time frame assessed in the NHDS to have an impact on the rates of obstruction. This hypothesis would be contradictory to the results demonstrated in the SCAR-3 trial, however, which demonstrated a possible plateau in rates of complications after 5 years²². Alternatively, SBO due to adhesions could be decreasing while SBO due to non-adhesion related causes was increasing. While we are unable to assess for the presence of prior abdominal surgery given the nature of NHDS data, one would expect to see decreasing rates in our analysis using the adhesion-specific diagnostic code alone if this were true. Rather, we saw stable rates. Finally, if the proportion of the population with prior intra-abdominal surgery has increased, then the size of the population at risk for post-operative adhesion related complications would be larger in successive years and the actual incidence of SBO could be decreasing in that population. However, when we examined trends in intra-abdominal surgery during the same time period, the annual rates per 100,000 population were decreasing as opposed to increasing.

There are several possible explanations for decreasing rates of adhesiolysis in two age groups, while rates of SBO remain stable. As previously mentioned, the widespread availability of parenteral nutrition, coupled with advancements in the ease of acquisition and breadth of imaging modalities may allow for increased use of supportive measures, decreasing the need for adhesiolysis while following patients for clinical resolution. These advances may have shifted the perceived risk benefit balance of observation versus adhesiolysis in favor of the nonsurgical approach, particularly in the elderly and those with multiple comorbidities. Another possibility is that while barrier methods may not have an effect on rates of SBO, these agents may influence the clinical course of SBO, reducing the need for surgical intervention. Furthermore, unmeasured effects of various medications prescribed for other medical conditions could potentially limit the need for such procedures via idiosyncratic effects on the course of adhesion-related SBO²³. These hypotheses should be assessed in future studies.

There are several potential limitations of this study. Use of survey data such as NHDS does not allow for assessment of individual-level characteristics or follow-up over time. Therefore, individual patients may contribute to multiple admissions in the same or different calendar years. This may explain the increasing rates of SBO in younger age groups, although overall rates remained low. Additionally, the NHDS does not allow one to estimate the rate of admission among the subgroup of the population who has had a prior intra-abdominal surgery and whether the prior surgery utilized a laparoscopy or barrier methods. However, this does not minimize the importance of these data from a public health perspective. It was not possible to determine the accuracy of the diagnostic and procedure codes used in our study, but any misclassification should not differ across study years. However, it is possible that there have been trends in coding patterns, such as increased coding for incidental adhesiolysis as part of another operation. Such changes could bias toward higher rates of adhesiolysis in the latter portion of the study period. However, when we examined adhesiolysis listed as the primary procedure and SBO as the primary diagnosis the results were similar to those reported here (data not shown).

In summary, SBO remains a major health problem. In this study sampling hospitals throughout the United States, rates of SBO have remained stable over the last two decades. The overall rates of adhesiolysis were stable as well, though there did appear to be small decreases in the oldest and youngest age categories. Developing safe and effective interventions to prevent post-operative SBO remains a priority.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Financial Support:

Financial support for this research was provided via an NIH Training grant, T32-DK007066-36 and K24-DK DK078228

References

1. Menzies D. Postoperative adhesions: their treatment and relevance in clinical practice. *Ann R Coll Surg Engl.* 1993 May; 75(3):147–153. [PubMed: 8323205]
2. Menzies D, Ellis H. Intestinal obstruction from adhesions—how big is the problem? *Ann R Coll Surg Engl.* 1990 Jan; 72(1):60–63. [PubMed: 2301905]
3. Wiseman DM, Trout JR, et al. The rates of adhesion development and the effects of crystalloid solutions on adhesion development in pelvic surgery. *Fertil Steril.* 1998 Oct; 70(4):702–711. [PubMed: 9797102]
4. Parker MC, Ellis H, Moran BJ, Thompson JN, Wilson MS, Menzies D, et al. Postoperative adhesions: ten-year follow-up of 12,584 patients undergoing lower abdominal surgery. *Dis Colon Rectum.* 2001 Jun; 44(6):822–829. discussion 9–30. [PubMed: 11391142]
5. Van Der Krabben AA, Dijkstra FR, Nieuwenhuijzen M, Reijnen MM, Schaapveld M, Van Goor H. Morbidity and mortality of inadvertent enterotomy during adhesiotomy. *Br J Surg.* 2000 Apr; 87(4):467–471. [PubMed: 10759744]
6. Diamond MP, Decherney AH. Pathogenesis of adhesion formation/reformation: application to reproductive pelvic surgery. *Microsurgery.* 1987; 8(2):103–107. [PubMed: 3306252]
7. Bizer LS, Liebling RW, Delany HM, Gliedman ML. Small bowel obstruction: the role of nonoperative treatment in simple intestinal obstruction and predictive criteria for strangulation obstruction. *Surgery.* 1981 Apr; 89(4):407–413. [PubMed: 7209787]
8. Parker MC, Wilson MS, Menzies D, Sunderland G, Thompson JN, Clark DN, et al. Colorectal surgery: the risk and burden of adhesion-related complications. *Colorectal Dis.* 2004 Nov; 6(6):506–511. [PubMed: 15521944]
9. Ellis H, Crowe A. Medico-legal consequences of post-operative intra-abdominal adhesions. *Int J Surg.* 2009 Jun; 7(3):187–191. [PubMed: 19389492]
10. Ray NF, Denton WG, Thamer M, Henderson SC, Perry S. Abdominal adhesiolysis: inpatient care and expenditures in the United States in 1994. *J Am Coll Surg.* 1998 Jan; 186(1):1–9. [PubMed: 9449594]
11. Kossi J, Salminen P, Rantala A, Laato M. Population-based study of the surgical workload and economic impact of bowel obstruction caused by postoperative adhesions. *Br J Surg.* 2003 Nov; 90(11):1441–1444. [PubMed: 14598429]
12. Ellis H, Moran BJ, Thompson JN, Parker MC, Wilson MS, Menzies D, et al. Adhesion-related hospital readmissions after abdominal and pelvic surgery: a retrospective cohort study. *Lancet.* 1999 May 1; 353(9163):1476–1480. [PubMed: 10232313]
13. Gutt CN, Oniu T, Schemmer P, Mehrabi A, Buchler MW. Fewer adhesions induced by laparoscopic surgery? *Surg Endosc.* 2004 Jun; 18(6):898–906. [PubMed: 15108105]

14. Taylor GW, Jayne DG, Brown SR, Thorpe H, Brown JM, Dewberry SC, et al. Adhesions and incisional hernias following laparoscopic versus open surgery for colorectal cancer in the CLASICC trial. *Br J Surg*. 2010 Jan; 97(1):70–78. [PubMed: 20013936]
15. Tang CL, Seow-Choen F, Fook-Chong S, Eu KW. Bioresorbable adhesion barrier facilitates early closure of the defunctioning ileostomy after rectal excision: a prospective, randomized trial. *Dis Colon Rectum*. 2003 Sep; 46(9):1200–1207. [PubMed: 12972964]
16. Vrijland WW, Tseng LN, Eijkman HJ, Hop WC, Jakimowicz JJ, Leguit P, et al. Fewer intraperitoneal adhesions with use of hyaluronic acid–carboxymethylcellulose membrane: a randomized clinical trial. *Ann Surg*. 2002 Feb; 235(2):193–199. [PubMed: 11807358]
17. Kumar S, Wong PF, Leaper DJ. Intra–peritoneal prophylactic agents for preventing adhesions and adhesive intestinal obstruction after non–gynaecological abdominal surgery. *Cochrane Database Syst Rev*. 2009; (1):CD005080. [PubMed: 19160246]
18. National Hospital Discharge Survey, 1987– 2009. Public Use File Documentation.. US Department of Health and Human Services Centers for Disease Control and Prevention. Hyattsville MD: National Center for Health Statistics;
19. United States Department of H, Human Services. National Center for Health S. National Hospital Discharge Survey, 1979–2006: Multi–Year Public Use File. Inter–university Consortium for Political and Social Research (ICPSR) [distributor]. 2009.
20. Ahmad G, Duffy JM, Farquhar C, Vail A, Vandekerckhove P, Watson A, et al. Barrier agents for adhesion prevention after gynaecological surgery. *Cochrane Database Syst Rev*. 2008; (2):CD000475. [PubMed: 18425865]
21. Zeng Q, Yu Z, You J, Zhang Q. Efficacy and safety of Seprafilm for preventing postoperative abdominal adhesion: systematic review and meta–analysis. *World J Surg*. 2007 Nov; 31(11):2125–2131. discussion 32. [PubMed: 17899250]
22. Parker MC, Wilson MS, Menzies D, Sunderland G, Clark DN, Knight AD, et al. The SCAR-3 study: 5–year adhesion–related readmission risk following lower abdominal surgical procedures. *Colorectal Dis*. 2005 Nov; 7(6):551–558. [PubMed: 16232234]
23. Srinivasa S, Kahokehr AA, Sammour T, Yu TC, Abbas SM, Hill AG. Use of statins in adhesive small bowel obstruction. *J Surg Res*. 2010 Jul; 162(1):17–21. [PubMed: 20452619]

Figure 1.

Rates of hospitalization for SBO per 100,000 persons from 1988 to 2007. Diamonds (◆) represent discharges for those 15–44 years old, triangles (▲) represent those 45 to 64 years of age, and circles (●) represent those 65 or older. There was no significant trend overall ($\rho=0.14$, $p=0.28$). Those 15–44 years old did have a significant upward trend ($\rho=0.70$, $p<0.01$), though events were low in this age group.

Figure 2.

Rates of hospitalization for adhesiolysis per 100,000 persons from 1988 to 2007. Circles (●) represent those 15–44 years old, diamonds (◆) represent those 45 to 64, and triangles (▲) represent those 65 and older. While there was no significant trend overall for adhesiolysis ($\rho = -0.17, p = 0.19$), there were statistically significant decreasing rates over time in those 15 to 44 ($\rho = -0.84, p < 0.01$), and those 65 and older ($\rho = -0.55, p = 0.01$).

Table I

Correlation between survey year and rate of diagnosis

Diagnostic Code	Range of rates of diagnosis ¹	Spearman's ρ	P-value
All SBO Codes	579.3 – 654.1	0.14	0.28
15–44	28.9 – 41.6	0.70	<0.01
45–64	120.8 – 155.8	0.31	0.19
>65	402.5 – 480.6	0.26	0.27
560.81 ²	136.9 – 198.0	–0.05	0.72
15–44	8.4 – 14.4	–0.37	0.11
45–64	32.5 – 58.0	–0.17	0.49
>65	92.3 – 143.1	0.11	0.63
560.89 ³	62.2 – 140.1	0.28	<0.01
15–44	1.1 – 9.3	0.90	<0.01
45–64	11.1 – 36.2	0.82	<0.01
>65	40.8 – 99.1	0.80	<0.01
560.9 ⁴	290.9 – 376.6	–0.04	0.77
15–44	13.3 – 20.6	0.20	0.39
45–64	64.6 – 84.6	–0.12	0.61
>65	204.5 – 284.0	–0.43	0.06
All Adhesiolysis Codes	485.3 – 595.9	–0.18	0.17
15–44	95.3 – 142.1	–0.84	<0.01
45–64	138.4 – 171.2	–0.16	0.49
>65	229.0 – 307.2	–0.55	0.01
Total Abdominal Surgeries	3341 – 4832	–0.29	0.03
15–44	653.5 – 979.8	–0.73	<0.01
45–64	1019 – 1425	–0.92	<0.01
>65	1669 – 2427	–0.92	<0.01
Adhesiolysis code with an associated abdominal surgery	388.5 – 500.1	–0.22	0.09
15–44	56.0 – 113.8	–0.88	<0.01
45–64	120.6 – 154.1	–0.43	0.057
>65	186.3 – 255.8	–0.65	<0.01
Adhesiolysis without an associated abdominal surgery	76.1 – 122.0	0.16	0.22
15–44	22.6 – 39.3	0.71	<0.01
45–64	11.2 – 27.6	0.44	0.05
>65	32.5 – 64.2	–0.01	0.96

¹ Rates are per 100,000 US citizens standardized by U.S. Census data

² 560.81 = “Intestinal or peritoneal adhesions with obstruction (postoperative) (postinfection)”

³ 560.89 = “Other specified intestinal obstruction”

⁴ 560.9 = “Unspecified intestinal obstruction”