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Postoperative wound dehiscence: predictors and associations

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Abstract

The Agency for Healthcare Research and Quality (ARHQ) patient safety indicators (PSI) were developed as a metric of hospital complication rates. PSI-14 measures postoperative wound dehiscence and specifically how often a surgical wound in the abdominal or pelvic area fails to heal after abdominopelvic surgery. Wound dehiscence is estimated to occur in 0.5–3.4% of abdominopelvic surgeries, and carries a mortality of up to 40%. Postoperative wound dehiscence has been adopted as a surrogate safety outcome measure since it impacts morbidity, length of stay, healthcare costs and readmission rates. Postoperative wound dehiscence cases from the Nationwide Inpatient Sample demonstrate 9.6% excess mortality, 9.4 days of excess hospitalization and $40,323 in excess hospital charges relative to matched controls.

The purpose of the current study was to investigate the associations between PSI-14 and measurable medical and surgical co-morbidities by using the Explorys technology platform to query electronic health record (EHR) data from a large hospital system serving a diverse patient population in the Washington DC and Baltimore, MD metropolitan areas. The study population included 25,636 eligible patients who had undergone abdominopelvic surgery between January 1, 2008 and December 31, 2012. Of these cases, 786 (2.97%) had post-operative wound dehiscence. Patient-associated co-morbidities were strongly associated with PSI-14, suggesting that this indicator may not solely be an indicator of hospital safety. There was a strong association between PSI-14 and opioid use after surgery and this finding merits further investigation.

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Keywords

Explorys; post-operative wound dehiscence; AHRQ; PSI-14

INTRODUCTION

The Agency for Healthcare Research and Quality (ARHQ) patient safety indicators (PSI)[1] were developed to provide information regarding hospital complications and adverse events following surgeries, procedures and childbirth. Literature review, data analysis and findings from clinical panels support the use of PSIs by organizations, purchasers and policymakers to identify safety problems at the hospital level, and to document systematic patient safety problems. The PSIs were developed after a comprehensive literature review, analysis of International Classification of Diseases, Ninth Revision—Clinical Modification (ICD-9-CM) codes, review by a clinician panel, implementation of risk adjustment, and empirical analyses. PSIs are used not only as a measure of hospital complications but also as a starting point to develop strategies to reduce preventable errors.

PSI-14 measures postoperative wound dehiscence and captures how often a surgical wound in the abdominal or pelvic area fails to heal after abdominopelvic surgery. Wound dehiscence is estimated to occur in 0.5–3.4% of abdominopelvic surgeries, and carries a mortality of up to 40%[2–4]. Postoperative wound dehiscence has been adopted as a surrogate safety outcome measure since it impacts morbidity, length of stay, healthcare costs and readmission rates. National rates of postoperative wound dehiscence are reported at 0.48 per 100,000 US residents with the Healthcare Cost and Utilization Project identifying a risk-adjusted rate of 1.11 per 1000 eligible patients in 2008[5]. Cases with wound dehiscence from the Nationwide Inpatient Sample had 9.6% excess mortality, 9.4 days of excess hospitalization and $40,323 in excess hospital charges relative to matched controls. Adjusting for age, gender, payer mix and co-morbidities, this quality indicator was associated with relative risk ratio of 1.57 for inpatient death, and relative risk ratio of 1.24 and 1.56 for readmission within one and three months respectively[5]. Additionally, data from the Veterans Administration database shows that rates of readmission are 61% higher for cases of postoperative wound dehiscence (CI, 1.27–2.05)[6].

PSI 14 is considered a hospital quality improvement and performance measure because it helps to identify potentially preventable complications of acute inpatient care. However, several studies have shown that postoperative wound dehiscence is additionally associated with patient related comorbidities including age, male sex, presence of chronic obstructive pulmonary disease (COPD), presence of ascites, congestive heart failure, hypertension, anemia, uremia, malignancy, obesity, sepsis, nutritional status and exposure to chronic steroids[2–4,7]. This suggests that PSI-14 may not purely be a measure of hospital quality and performance. A chart review case-control study of patients with and without wound dehiscence through the Veterans Administration system could not identify differences in care between cases and matched controls, but did find an association between postoperative wound dehiscence and medical and surgical co-morbidities[8]. Given the large number of associated risk factors, several models have been devised to stratify risk for post-operative wound dehiscence. Using data from a single center in the Netherlands, van Ramshorst et al. proposed a model with specific risk scores ranging from 0.4–1.9 for such variables as age, male gender, chronic pulmonary disease, ascites, jaundice, anemia, emergent setting, type of surgery, coughing, and wound infection[7]. Wound infection was given the highest risk score of 1.9. Total risk scores greater than 8.0 were associated with a 66.5% chance of wound dehiscence. Similarly, in a multi-center study across Veterans Affairs medical centers, Webster et al. devised a risk stratification model that assigned between 2 and 17 points for such factors as previous stroke, history of COPD, current pneumonia, emergent setting, operative time of longer than 2.5 hours, PGY4 level resident as surgeon, superficial and deep wound infection, failure to wean, and one or more complications[3]. Deep wound infection was the factor given the highest risk score of 17. Clean wound classification received a score of −3, and return to the OR was given a score of −11. Risk scores of greater than 14 were categorized as very high and involved an observed incidence of wound dehiscence of 9.15%.

Despite advances in postoperative care and a better understanding of risk factors, wound dehiscence remains a national healthcare quality concern such that it is one of the publicly reported outcome measures for the Center for Medicare and Medicaid Services (CMS) and AHRQ[1,5]. With growing public attention into quality outcomes data, hospitals are facing increasing pressure to understand these quality metrics and improve performance in these areas. The Explorys technology platform (Explorys, Inc.) utilizes a health data gateway (HDG) server to collect data from a variety of health information systems including electronic health records (EHR), billing systems, and laboratories. This data is automatically updated once every 24 hours. In Explorys, patient records are mapped to the Systematized Nomenclature for Medicine-Clinical Terms (SNOMED-CT), a single set of Unified Medical Language System (UMLS) ontologies to assist with searching and indexing. To date only a small number of studies have been published utilizing the Explorys platform[9–12] and no study has investigated PSIs using this methodology. A correlative chart review study has shown that the inclusion and exclusion criteria for PSI-14 have a strong predictive ability to identify true cases of postoperative wound dehiscence[13], thus this indicator is ideally suited for cohort discovery in electronic healthcare databases.

The purpose of the current study was to use the Explorys technology platform to investigate the associations between postoperative wound dehiscence, as defined by the AHRQ PSI-14, and underlying measurable medical and surgical co-morbidities using EHR data from the MedStar Health System. We hypothesized that PSI-14 would be associated with measurable patient-related co-morbidities. We secondarily investigated the relationship between PSI-14 and exposure to various medication classes.

METHODS

This study was approved by the Georgetown Howard Universities Center for Clinical and Translational Science Institutional Review Board (IRB 2013-0387).

Study population

MedStar Health is a network of 10 hospitals and 20 other facilities across Maryland and Washington, DC. The health system has more than 163,000 inpatient admissions and more than 2 million outpatient visits each year, serving more than a half-million patients annually. Operating in urban and non-urban locations, MedStar Health serves a diverse patient population and offers a wide variety of healthcare services.

Explorys Technology Platform and Data Security

Data was collected using the Explore application in the Explorys technology platform (Explorys, Inc.). Data used in Explore is de-identified according to HIPPA and HITECH standards and mapped into UMLS ontologies to facilitate data collection and querying. Patients are assigned unique identifier codes, which allow longitudinal documentation of clinical care across all participating institutions. This methodology has been independently validated and reviewed by the RAND Corporation and found to be an accurate methodology for improving algorithm accuracy rates for patient matching[14]. SNOMED-CT hierarchy is used to map diagnoses, findings and procedures. SNOMED and RxNorm are used to map prescribed medication to pharmacological class and drug identities respectively. Logical Observation Identifiers Names and Codes (LOINC) hierarchy is used to map laboratory test observations. This data is automatically updated every 24 hours.

Validation of Explorys data

Prior to using the Explorys platform in this study, internal data validation was completed by comparing data output from Explorys with patient records in the various MedStar EHR systems. This validation was completed by the Quality Assurance Division of the MedStar Health Information Technology Department.

Cohort discovery

Cases of abdominopelvic surgery and postoperative wound dehiscence were identified from the MedStar Health System cohort between January 1, 2008 and December 31, 2012 based on the AHRQ inclusion criteria for this patient safety indicator. Ordinarily, the technical specifications for the AHRQ PSI-14 indicator exclude patients with any diagnosis or procedure code for an immunocompromised state, but in this study we elected to investigate the cohort both with and without patients with autoimmune diseases.

Inclusion criteria—The study population included all qualifying patients age >18 who underwent inpatient abdominopelvic surgery with a length of stay >2 days. The cases were selected based on the ICD-9-CM code for "re-closure of postoperative disruption of an abdominal wall" (546.1).

Exclusion criteria—Patients with incomplete demographic data (missing gender, age, or principal diagnosis) and those associated with pregnancy, childbirth and the puerperium were excluded.

Co-morbidities

The following patient characteristics and comorbidities were included in the regression analysis: Age (as both a continuous variable and stratified >65 vs. <65), sex, presence of chronic obstructive pulmonary disease (COPD), diabetes mellitus (DM), jaundice, autoimmune disease (based on ICD-9-CM codes for rheumatoid arthritis 714.0, systemic lupus erythematosus 710.0, scleroderma 710.1, mixed connective tissue disease 710.9, sjogrens syndrome 710.3 and myositis 710.3), ascites, anemia (Hct <30%), type of surgery (based on Current Procedural Terminology (CPT) codes), cancer diagnosis, body mass index (BMI >30kg/m^2) and nutritional status (albumin <3.5g/dL). The Explorys prescription order database was queried to obtain data on medication exposures prior to and after the index surgery, specifically exposure to immunosuppressive agents and opioid analgesics. Based on the provider of record at the time of surgery, the institution at which surgery was performed was determined. Institutions were categorized into community hospitals vs. tertiary care centers for analysis. The date of surgery was used to determine whether surgery was performed on a weekday or on a weekend.

Statistical Analysis

Statistical analysis was performed using STATA statistical software (version 11; StataCorp LP, College Station, TX, USA).

Descriptive statistics such as means and standard deviations for continuous variables and frequencies as well as percentages for categorical variables were used to summarize the basic characteristics of the overall sample by wound dehiscence status. Chi-squared tests, two sample t-tests, Fisher's exact tests and Mann-Whitney U tests were used, as appropriate to examine the differences between the groups. Multivariate logistic regression models were used to examine associations between comorbidities and post-operative wound dehiscence and to identify the factors most strongly associated with PSI-14. All significance tests were two-tailed and P<0.05 was considered significant.

RESULTS

Using the Explorys platform, 25,636 eligible patients were identified who had undergone abdominopelvic surgery in the MedStar Health System cohort between January 1, 2008 and December 31, 2012. Of these cases, 786 (2.97%) had post-operative wound dehiscence.

Demographic associations with PSI-14

Patients with dehiscence were significantly older, more commonly male, and had a higher BMI (p<0.0001, Table 1). There were no significant associations between baseline blood pressure, hemoglobin A1c, or presence of autoimmune disease between the patients with and without dehiscence.

Patient-related Co-morbidities associated with PSI-14

Multivariate logistic regression was used to develop several models to identify variables associated with PSI-14. Infection was clearly the most strongly associated patient-related comorbiditiy, but other patient-related co-morbidities associated with PSI-14 in this cohort included COPD, ascites, anemia, albumin <3.5, and diabetes (Table 2). These comorbidities remained significantly associated with wound dehiscence when adjusted for age, gender and BMI. Use of immunosuppressive agents and opioid agents within 100 days prior to the index surgery was not associated with PSI-14. However, exposure to opioid agents in the 30 days following surgery was associated with PSI-14 and this remained a significant association even when infection was removed from the model (Table 2, Model D, OR1.602, p<0.001).

Relationship between institution type and day of surgery with PSI-14

In this cohort, there was no significant correlation between institution types (tertiary care vs. community hospital) and PSI-14. However, even when infection was excluded from the model, weekend surgeries were more commonly associated with PSI-14 than weekday surgeries (Table 2, model D OR 1.319, p<0.001). Additional details to more accurately stratify surgeries into elective vs. emergent cases were not available using the Explorys platform.

Relationship between surgery type and PSI-14

Prevalence of post-operative wound dehiscence was compared among the different types of eligible surgeries pulled from the Explorys data set using CPT codes. As expected the lowest rates of wound dehiscence were seen in urologic and prostate surgery. Highest rates of wound dehiscence were seen in hernia (4.04%) and vascular surgeries (5.7%). Further interpretation of this data was limited because a large number of the eligible surgeries fell into the classification other abdominopelvic surgery not otherwise specified.

DISCUSSION

Several studies have investigated the use of the Explorys platform for investigating outcomes in large clinical populations[9–12]. However, this is the first study to use Explorys to investigate associations with PSIs and to combine analysis of the relationship between patient related co-morbidities and medication exposures. The data presented supports the findings of prior studies demonstrating that that several patient-associated co-morbidities including infection, COPD, ascites, anemia, albumin <3.5, and diabetes are significant risk factors for PSI-14. This finding is reassuring since it validates the findings of prior studies in an independent cohort, and provides evidence that utilization of the Explorys platform for investigating surgical outcomes, particularly PSI-14, provides robust data similar to that seen from data collected using other established methodologies. Furthermore, the use of the Explorys data platform allowed the investigators to uniquely study the relationship between PSI-14 and institution type in addition to medication exposures. While PSI-14 is known to correlate with increased morbidity, length of stay, healthcare costs and readmission rates[7], our data suggests that patient-related factors may significantly contribute to PSI-14 independent of the location of care (tertiary vs. community hospital).

In this study, several surgical cohorts were associated with a significantly higher prevalence of postoperative wound dehiscence. It is perhaps not unsurprising to see a higher prevalence of postoperative wound dehiscence in patients undergoing hernia surgery. However, the relatively high prevalence of wound dehiscence in the vascular surgery cohort in this study merits further evaluation. It could be inferred that subjects undergoing abdominopelvic surgery for a vascular intervention are more likely to have associated comorbidities such as diabetes and peripheral vascular disease. Additionally, vascular surgeries are often more prolonged and complex and are more likely to be done in an emergent setting. However, it is also possible that this association is a biologic phenomenon related to either endothelial injury, impaired angiogenesis or collagen defects in these patients. The relationship between vascular surgery, vascular disease and postoperative wound dehiscence merits investigation in future studies.

Prior work investigating patients with chronic wounds has demonstrated that autoimmune diseases are associated with impaired wound healing[15–18]. However, in this cohort we did not find an association between PSI-14 and autoimmune disease. Additionally, in this large data set we could not demonstrate any significant correlation between immunosuppressive use prior to surgery and the development of post-operative wound dehiscence.

After controlling for other comorbidities, we did find a correlation between opioid exposure after index surgery and PSI-14. Opioid analgesics are commonly used for management of postoperative pain. However, to date there have been no large studies investigating the impact of clinical use of opioid analgesics in human wound healing. Molecular studies investigating keratinocyte biology and wound healing have shown that functionally active μ-opiate receptors are present on human keratinocytes[19]. Activation of these receptors in cultured keratinocytes results in upregulation of molecular pathways that are known to play an important role in promoting wound healing[20]. However, other studies have suggested that opioid use has an immunosuppressive effect and may compromise hemodynamic and host defense responses[21] which negatively impacts wound healing by reducing immune activation and myofibroblast recruitment as well as impacting keratinocyte cytokine production, endothelial proliferation and angiogenesis[22–24]. The observation in this large clinical cohort that opioid analgesic use in the post-operative period was associated with PSI-14 merits further investigation. It is highly likely that patients with incipient wound dehiscence have more pain, and thus higher opioid exposure. However, the observation also raises concern that that perhaps opioid exposure during this critical postoperative period could adversely impact healing either via impacting keratinocyte biology or by increasing propensity to wound infection. Since aggressive treatment of pain with opioid analgesia is currently standard of care in the United States, it is important that further studies are done to investigate the impact of opiates on wound healing.

This study has several limitations which merit discussion. The use of EHR data always introduces concerns related to inaccurate coding and incomplete EHR records. To minimize the likelihood of inaccuracies in coding, the period of data included in this study (2008–2012) was selected since it coincides with full implementation of EHR throughout the MedStar Health system, and during this timeframe we believe clinical databases were maintained accurately. While coding data may have impacted accuracy of cohort discovery, a correlative chart review study has shown that the inclusion and exclusion criteria for PSI-14 have a strong predictive ability to identify true cases of postoperative wound dehiscence[11]. Furthermore, prior to using the Explorys platform in this study, internal validation was completed by comparing data output from Explorys with patient records in the various MedStar EHR systems, and this was found to be a valid method for collecting data within the MedStar Health system.

A further limitation of this study was that data abstracted using the Explorys platform did not accurately stratify surgical cases into elective vs. emergent surgeries. While we could have performed subgroup analysis based on admission type (elective vs. emergency) this would not have captured the critical data on whether the index surgery was performed electively or emergently. Since the variable most likely to influence wound dehiscence is the operative scenario (including the organization of the surgical team, nursing staff, anesthesia and perioperative team) it was felt that using the day of surgery stratified into weekday vs. weekend would more accurately capture this issue than using the admission type. The data presented found that weekend surgeries were more commonly associated with PSI-14 than weekday surgeries even after controlling for infection (OR 1.319, $p<0.001$). This suggests that given the physical plant of the institution is not changing between the weekday and weekend, team related factors including staffing levels, staff fatigue and staff seniority may more likely be influencing this outcome. There is good data that emergency general surgery patients are at substantially greater risk than elective general surgery patients for adverse events. Our data is consistent with that of others that hospitals do not have highly consistent performance across emergent and elective general surgery outcomes[25]. This may further account for some of the differences seen in certain surgery types and merits additional investigation to assess whether quality and process improvement strategies can be deployed to improve outcomes in these high-risk surgical subgroups.

Finally, administrative coding data does not accurately capture hospital and team level strategies addressing peri-operative quality improvement which are likely to impact surgical outcomes. Even so, the data presented suggest that improving understanding of the patient-related co-morbidities associated with PSI-14 may help surgical teams both better advise patients of their risk prior to surgery, and will also enable surgical teams to focus on modifiable risk factors prior to elective surgeries.

CONCLUSION

This study provides proof of concept that the Explorys platform allows investigators to harness large multicenter healthcare networks to explore the relationships between clinical co-morbidities, medication exposures, and positive and negative clinical outcomes in large populations. Patient-associated co-morbidities were strongly associated with PSI-14, suggesting that while this indicator correlates with increased length of stay, healthcare costs and readmissions it may not solely be an indicator of hospital safety.

One of the very unique features of this study is the data presented correlating PSI-14 and medication exposures. Analysis of this data suggests an association between PSI-14 and opiate exposure. This unique and important data could not have been feasibly or reliably collected prior to the use of the Explorys platform, and while the current study was not designed to demonstrate causality, these findings merit further investigation.

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Table 1

Demographic characteristics for patients with and without postoperative wound dehiscence, data presented as mean ± standard deviation

	Without dehiscence N=25636	With dehiscence N=786	Mean difference or Odds Ratio (95% CI)	P
Age	51.67±17.20	55.05±16.44	−3.38(−4.60, −2.16)	<0.0001
Body Mass Index (BMI)	28.40±7.85	29.99±9.75	−1.59(−2.22, −0.96)	<0.0001
Systolic Blood Pressure	127.57±19.41	128.39±19.98	−0.82(−2.38, 0.73)	0.30
Diastolic Blood Pressure	73.26±11.59	72.81±11.81	0.45(−0.48, 1.38)	0.34
Hemoglobin A1c (note: data on HbA1c was only available on 4343 patients)	6.70±1.84	6.71±1.60	−0.01(−0.27, 0.24)	0.92
Gender				
Women	17266/17739(97.33%)	473/17739(2.67%)	0.73 (0.63–0.85)	<0.0001
Men	8370/8683(96.40%)	313/8683(3.60%)		
Diabetes, N (%)				
Yes	4910/5159 (95.2)	249/5159 (4.8)	1.96 (1.68–2.28)	<0.0001
No	20726/21263 (97.5)	537/21263 (2.5)		
COPD, N (%)				
Yes	2807/2965 (94.7)	158/2965 (5.3)	2.05 (1.71–2.45)	<0.0001
No	22829/23457 (97.3)	628/23457 (2.7)		
Ascites, N (%)				
Yes	1466/1576 (93.0)	110/1576 (7.0)	2.68 (2.18–3.30)	<0.0001
No	24170/24846 (97.3)	676/24846 (2.7)		
Anemia, N (%)				
Yes	9522/9948 (95.7)	426/9948 (4.3)	2.00 (1.74–2.31)	<0.0001
No	16114/16474 (97.8)	360/16474 (2.2)		
Jaundice, N (%)				
Yes	287/304 (94.4)	17/304 (5.6)	1.95 (1.19–3.20)	0.008
No	25349/26118 (97.1)	769/26118 (2.9)		
Infection, N (%)				
Yes	28/299 (9.4)	271/299 (90.6)	481.26 (323.01–717.04)	<0.0001
No	25608/26123 (98.0)	515/26123 (2.0)		
Pneumonia, N (%)				
Yes	223/248 (89.9)	25/248 (10.1)	3.74 (2.46–5.70)	<0.0001
No	25413/26174 (97.1)	761/26174 (2.9)		
Autoimmune disease, N (%)				
Yes	569/596 (95.5)	27/596 (4.5)	1.57 (1.06–2.32)	0.025
No	25067/25826 (97.1)	759/25826 (2.9)		

Table 2

Multivariate logistic regression models of variables associated with PSI-14 presented as odds ratios (Standard error), significance levels indicated by * are presented (* <0.05, ** p<0.01, *** p<0.001).

	MODEL A Including BMI (n=16,432)	**MODEL B Excluding BMI (n=24,377)**	**MODEL C Excluding infection (n=16,432)**	**MODEL D Excluding BMI and infection (n=24,377)**
Tertiary vs. community hospital	1.414 (0.27)	1.404 (0.28)	1.263 (0.33)	1.266 (0.32)
Day of surgery (Weekend vs. weekday)	1.236* (0.12)	1.17 (0.12)	1.455*** (0.11)	1.319*** (0.09)
Age	0.998 (0.00)	0.998 (0.00)	0.997 (0.00)	0.999 (0.00)
BMI	1.036*** (0.01)		1.030*** (0.01)	
Female Gender	0.659** (0.09)	0.665** (0.10)	0.758 (0.12)	0.741 (0.12)
Diabetes	1.169 (0.11)	1.368** (0.15)	1.323*** (0.04)	1.425*** (0.07)
COPD	1.635** (0.28)	1.583** (0.26)	1.324 (0.25)	1.350* (0.20)
Ascites	1.837*** (0.34)	1.625** (0.30)	1.787** (0.33)	1.643** (0.25)
Anemia	1.328*** (0.09)	1.360*** (0.04)	1.427*** (0.07)	1.441*** (0.09)
Jaundice	1.293 (0.27)	1.073 (0.24)	1.196 (0.23)	1.037 (0.24)
Infection	1009.08*** (253.24)	1307.77*** (343.78)		
Pneumonia	1.981** (0.42)	1.928** (0.45)	2.257*** (0.34)	2.049*** (0.34)
Autoimmune disease	0.821 (0.25)	0.927 (0.25)	0.975 (0.13)	1.166 (0.16)
Immunosuppressive drug prior to surgery	0.834 (0.29)	0.833 (0.25)	0.77 (0.30)	0.995 (0.17)
Immunosuppressive drug after surgery	1.371* (0.21)	1.379* (0.22)	1.235 (0.14)	1.344* (0.16)
Opioid drug prior to surgery	0.993 (0.16)	1.060 (0.15)	1.015 (0.09)	1.017 (0.08)
Opioid drug after surgery	1.597*** (0.15)	1.673*** (0.22)	1.532*** (0.14)	1.602*** (0.18)

Table 3

Type of surgery and prevalence of post-operative wound dehiscence, (Pearson Chi-squared test for all surgery types, $p<0.0001$)

	No dehiscence	Dehiscence	% dehiscence
Gynecology	1675	42	2.44%
Hernia	1661	70	**4.04%**
Laparoscopy	606	19	3.04%
Laparotomy	2671	95	3.43%
Other Abdomino-pelvic NOS	16549	529	3.1%
Prostate/seminal vesicles	1123	2	0.12%
Urologic	1135	16	1.4%
Vascular	216	13	**5.7%**