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Temporal Trends in Permanent Pacemaker Implantation:

A Population-Based Study

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Abstract

Background—Limited data exist regarding temporal trends in permanent pacemaker (PPM) implantation. To describe trends in incidence and comorbidities of (PPM) recipients, we conducted a retrospective population-based cohort study over a 30-year period.

Methods—All 1291 adult residents of Olmsted County, Minnesota undergoing PPM implantation between 1975–2004 were included in the study. Trends in PPM implantation incidence, pacing mode and indication, and comorbidities (via Charlson comorbidity index [CCI]), were assessed through the Rochester Epidemiology Project. PPM recipients were compared with age- and sex-matched PPM-free controls from the population.

Results—Adjusted implant incidence rates increased from 36.6 per 100,000 person-years during 1975–1979 to 99.1 per 100,000 person-years during 2000–2004 ($p<0.0001$). After adjusting for age (hazard ratio [HR] 1.06 per year), male sex (HR 1.28), and implant year (HR 0.98) the HR for death by CCI quartiles was 1.0, 1.79, 2.29, 3.91 for CCI of 0–1 (reference), 2–3, 4–6, and ≥ 7 , respectively ($p<0.0001$). Overall, PPM recipients had higher CCI than the population-based controls ($p=0.04$), with higher mean CCI noted since 1990. Mean age-adjusted CCI increased from 3.15 to 4.60 among the cases ($p<0.0001$) and from 3.06 to 3.54 among the age- and sex-matched controls ($p=0.047$).

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Conclusions—There have been significant increases in incidence of PPM implantation over 30 years, and PPM recipients have had an age-independent increase in comorbidities relative to the underlying population, especially over the past 15 years.

Keywords

Pacemakers; aging; epidemiology; survival; population

INTRODUCTION

Advances in permanent pacemakers (PPM) have resulted in tremendous changes in the care of patients with a wide range of cardiac diseases, including atrioventricular block, sinus node dysfunction, and congestive heart failure^{1, 2}. PPM usage has increased due to several factors, including an aging population, advances in device technology, and an increasing number of indications for their use². Multiple studies have shown improvements in quality of life, exercise capacity, and disease progression³⁻⁸. There have been no recent population-based studies that analyzed temporal trends in the implantation of PPM. This study was undertaken to examine the temporal trends in PPM implantation over the past 30 years, and to assess changes in comorbidities of PPM recipients.

METHODS

Setting

Olmsted County is located in Southeastern Minnesota and has population characteristics similar to those of US non-Hispanic whites⁹. The population according to the 2000 census was 124,277¹⁰. The Rochester Epidemiology Project (REP) is a medical record-linkage system that indexes medical records from all individuals seen by an Olmsted County healthcare provider and residing in Olmsted County. A single medical dossier exists for each patient, into which medical diagnoses, surgical interventions, and other key information from medical records are regularly abstracted and coded into computerized indices using the International Classification of Diseases, Adapted Code for Hospitals^{9, 11}. The computerized indices allow the linkage of medical records from all sources of care used by the population, which provides an infrastructure to analyze disease determinants and outcomes. Included in REP dossiers are histories and diagnoses for all patient encounters with the healthcare system, including both hospitals in Olmsted County (Mayo Clinic and Olmsted Medical Center).

Case ascertainment

All adult (≥ 18 years at time of PPM implantation) residents of Olmsted County undergoing PPM implantation between 1975 and 2004 were included in the cohort. Nonresidency in Olmsted County at the time of device implantation was an exclusion criterion; therefore patients whom underwent PPM placement elsewhere and then relocated to Olmsted County were not included. Patients were only included as incident cases during their initial PPM implantation. Patients with cardiac resynchronization devices were not included as incident cases.

Charlson Comorbidity Index (CCI)

To assess comorbidities, we used the modified Charlson Comorbidity Index (CCI), which utilizes administrative databases which record ICD-9 diagnoses^{12, 13}. The modified CCI consists of 17 different disease comorbidity categories, weighted from 1 to 6 based on adjusted relative risk of 1-year mortality, and summed to provide a total score¹³. To validate the CCI as a predictor of mortality in PPM recipients, patients were grouped into quartiles by their CCI score. Patients were followed until death or censoring (for example, moving out of Olmsted

County). The county population is stable overall, and health status has little influence on migration.¹⁴ Deaths were confirmed with Minnesota electronic death certificate data or clinical documentation, as previously described.¹⁴

To assess whether temporal trends in CCI were simply due to shifts in the underlying population demographics of Olmsted County, implant cases were matched to PPM-free control subjects randomly selected from the population. Potential pacemaker-free control subjects were identified from the community via the REP⁹. For every case in the PPM cohort, the year of initial device implantation was defined as the index year and a device-free control was randomly selected from the Olmsted County population, matched by sex and age (within one year of birth). Control subjects all had a medical encounter within the same year as the matched case's device implant. All patients in the control population who met these criteria were regarded as eligible, irrespective of any possible diseases or risk factors (population-based control sample). Based on these criteria we were able to successfully match 1128 controls to the 1291 PPM cases. The unmatched cases did not differ significantly from the matched cases by age, sex, or CCI.

Data analysis

Device implantation rates were derived using the population from decennial US census figures, disaggregated by sex and by single year of age, as the denominator, with a population growth rate of 1.9% projected for years after 2000. From the age- and sex-specific census counts, we obtained counts for the intercensal years by assuming linear growth of the population between censuses (a constant increment from one year to the next). Poisson regression was used to compare changes in incidence of implantation over time. Survival curves were estimated by the Kaplan-Meier method. Associations between variables (including age, year of implant, sex, implantation status, and Charlson comorbidity index) and long-term survival were examined by univariate and multivariable Cox proportional-hazards regression analysis. Intra-group comparisons in Charlson Comorbidity Index among PPM recipients and the control population and pairwise comparisons at each year interval were analyzed with an ANOVA model comparing the Charlson Comorbidity Index least squares mean, adjusted for age. .

RESULTS

Between 1975 and 2004, 1291 adult patients underwent PPM implantation. Mean age at PPM implantation was 76 ± 12.6 years, and 52% were female. Age- and sex-adjusted incidence (per 100,000 person-years) of PPM implantation in Olmsted County was calculated and adjusted to the US white 2000 population. The incidence of PPM placement by five year interval is shown in Table 1. Adjusted incidence increased from 36.6 per 100,000 person-years in 1975-79 to 99.0 per 100,000 person-years in 2000-04 (incidence density ratio 2.73, 95% CI 2.14 - 3.48, $p < 0.0001$). The age-adjusted incidence trends in PPM placement by sex are shown in Figure 1. The incidence of implantation in men was significantly greater than women during the entire 30-year period ($p < 0.0001$).

PPM implantation increased across all age groups. Incidence rates (adjusted for sex) increased significantly within each age quartile via the Poisson regression model (Figure 2). PPM implant incidence increased from 7.06, 140.7, 306.2, and 422.0 per 100,000 person-years in 1975-79 for age quartiles 18-69, 70-79, 80-84, and 85-110 respectively to 21.5, 364.1, 901.6, and 1026.8 per 100,000 person-years in 2000-2004 ($p < 0.0001$ for all trends). Utilization of dual chamber pacing mode increased over time, from 18.6% of device recipients in 1980-84 to 71.2% of patients in 2000-2004 ($p < 0.0001$). Overall 646 (56.4%) of device recipients received dual chamber PPMs. Temporal trends in pacing mode are shown in Figure 3.

Indications for PPM placement were obtained via review of operative reports and are shown in Figure 4. Overall there was a trend toward implantation for indications other than atrioventricular block, including sinus node dysfunction and carotid sinus hypersensitivity (likelihood ratio $p<0.0001$). Patients receiving PPM for congestive heart failure or hypertrophic cardiomyopathy comprised less than 3% of the total. Overall 55.24% of PPM recipients had an indication of atrioventricular block, 22.77% sinus node dysfunction, 10.03% bilevel conduction disturbance (both atrioventricular block and sinus node dysfunction), 9.34% carotid sinus hypersensitivity, and 2.61% cardiomyopathies, including hypertrophic cardiomyopathy and congestive heart failure.

The most common co-morbid conditions comprising the CCI among PPM recipients were congestive heart failure (549 patients, 47.9%), chronic pulmonary disease (458 patients, 39.9%), cerebrovascular disease (393 patients, 34.3%), diabetes (366 patients, 32.4%, including 103 with renal, ophthalmic, or neurologic manifestations), myocardial infarction (361 patients, 31.9%), and any malignancy (including leukemia and lymphoma) (326 patients, 28.5%). The median weighted CCI among PPM recipients was 3 (range 0 to 19; interquartile range 2 to 6).

The overall 5-year survival after implantation was 58.2%. Five-year survival of PPM implant recipients by CCI quartile is shown in Figure 5. Five-year survival was 84.5%, 59.3%, 50.0%, and 29.9% for patients with CCI of 0-1, 2-3, 4-6, and ≥ 7 , respectively ($p<0.0001$). After adjusting for age (hazard ratio [HR] 1.06 for a one-year increase, 95% CI 1.05 - 1.07), male sex (HR 1.28, 95% CI 1.09 - 1.50), and implant year (HR 0.98, 95% CI 0.97 - 0.99) the HR for death by CCI quartile was 1.0, 1.79, 2.29, 3.91 for CCI of 0-1 (reference), 2-3, 4-6, and ≥ 7 , respectively (all $p<0.0001$).

Temporal trends in CCI, adjusted for age at implant, are shown in Figure 6. There were statistically significant trends in CCI in both cases and controls in the ANOVA model. After adjusting for age at implant, mean CCI increased from 3.15 to 4.60 over the study period among the PPM recipients ($p<0.0001$) and from 3.06 to 3.54 among the controls ($p=0.047$). Overall PPM recipients had a statistically significant higher mean Charlson Index than controls in the adjusted model ($p=0.04$). The mean Charlson Index was higher among cases than controls in years from 1990 through 2004 (p -values 0.01, 0.006, and <0.0001 for year groups 1990-94, 1995-99, and 2000-04, respectively). No difference was noted when comparing the mean Charlson Index among cases versus controls during 1975 through 1989.

Discussion

In our large geographically defined cohort of 1291 PPM recipients over 30 years, there were dramatic increases in the incidence of PPM implantation. Reasons for the increase in PPM implantation likely include the expanding indications for PPM implantation, changes in the population, and advances in device technology. The comorbidities of PPM recipients as indexed by the CCI increased significantly, especially over the past 10 years. This does not appear to simply reflect aging of the underlying population, given the difference in CCI between cases and matched control subjects. As the CCI is a valid predictor of survival in this population, increased CCI in PPM recipients has prognostic implication in patients undergoing device implantation.

Overall, the current population undergoing PPM implantation has more comorbidities than ever before, despite adjusting for age. Possible explanations could be increasing aggressiveness on the part of physicians who implant PPM, or the expanding indications for device implantation, including sinus node dysfunction, neurocardiogenic syncope, and congestive heart failure^{1, 2, 15}. Our analysis of trends in implant indication indicated a statistically

significant trend toward decreased proportion of implant for AV block, and increases for carotid sinus hypersensitivity, sinus node dysfunction, and bilevel conduction disturbances. Further studies addressing the evolving indications for PPM placement and the subsequent impact on implantation rates will be necessary to determine the driving force behind these trends.

The benefits of permanent pacemaker implantation include other factors beside increased survival such as improvement of bradycardia-related symptoms, quality of life, and exercise tolerance³⁻⁸. With increases in implant incidence as well as comorbidity, physicians may be choosing to implant PPM increasingly for reasons other than simply prolonging survival. Implant year was a statistically significant predictor of survival, suggesting that despite increasing trends in comorbidity there has been improved survival in patients undergoing device implantation over time. This could be related to advances in device technology, or overall better care of cardiovascular patients due to improved diagnosis and treatment of diseases such as hyperlipidemia and hypertension.

Studies of PPM outcome may be hampered by the wide age range and comorbidities associated with varying indications for implantation. Comorbid illness has been previously shown to be strongly associated with long-term survival in patients with coronary disease^{16, 17} and with heart failure¹⁸. Initially developed in 1987 by Charlson and colleagues from risk factors that predicted 1-year survival in a cohort of medical inpatients, the CCI is a widely used and well-validated index of comorbid conditions^{12, 13}. In the present study the CCI was a valid predictor for survival in a multivariate logistic regression model including age and sex. Validation of the CCI as a predictor of mortality in PPM patients allows for use of this variable for adjustment based on case mix in nonrandomized studies of PPM, or as a clinical aid in predicting survival in the PPM patient population.

Cabell et al¹⁹ and Voigt et al²⁰ found that rates of PPM infection were increasing at a much higher rate than respective prevalence trends, for reasons that were unclear. We speculate that increasing complication rates, including infection, may be due to shifting demographics of PPM recipients such as increasing comorbidity.

Multiple studies have assessed trends in device utilization by surveying implanting physicians and manufacturers of cardiac devices^{15, 21, 22}. Our study, however, provides the first population-based calculation of PPM implantation incidence, and the first to assess temporal trends in medical comorbidities. The essentially complete ascertainment of all PPM implantations in our study in a well-established medical record linkage system for a population of known size and age distribution allows an unbiased and accurate estimation of the PPM implantation incidence rate, trends, and survival.

Our study is limited by several factors. The racial and ethnic composition of Olmsted County is relatively homogenous compared to the rest of the U.S., which limits the generalizability of our study to groups underrepresented in the population. However, prior studies of chronic diseases in Olmsted County have indicated that results can generally be extrapolated to a large part of the population⁹. While our study was population-based and not limited to a referral practice, Mayo Clinic is a well-known academic practice and tertiary medical center. The practice patterns in our community may not therefore be entirely representative of general cardiac practice in the rest of the United States, although to a large extent the institution provides the primary cardiology care for Olmsted County. A previous nationwide study of PPM implant epidemiology did not show significant regional variation²². Lastly, while CCI obtained from ICD-9 codes has been shown to predict postoperative complications, mortality, length of hospital stay, and hospital charges, it may not provide a complete identification of comorbid disease compared with clinical databases or vigorous chart review¹³. For example, "heart failure" as classified by ICD-9 codes may not take into account differing etiologies for heart

failure or distinguish normal versus reduced ejection fraction¹⁸. However, prior studies of similar databases examining the outcome of lumbar spine surgery reported that primary diagnosis and procedure codes were correctly recorded 96% of the time when compared with medical record reviews^{13, 23}. While the CCI as computed might be sensitive to changes in diagnostic coding over time^{9, 24}, any biases that it might have are likely distributed equally among the cases and control subjects. Multiple studies from different countries have shown that CCI can adequately identify the presence of comorbid disease to control for differences in case-mix between patient populations²⁵⁻²⁸.

The present study of temporal trends in permanent pacemaker implantation includes the largest cohort examined to date, and is the first to address trends in a geographically defined population. There were significant increases in medical comorbidities (as defined by the Charlson Comorbidity Index) in PPM recipients.

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REFERENCES

1. Hayes DL, Furman S. Cardiac Pacing: How It Started, Where We Are, Where We Are Going. *Journal of Cardiovascular Electrophysiology* 2004;15(5):619–627.
2. Gregoratos G, Abrams J, Epstein AE, Freedman RA, Hayes DL, Hlatky MA, et al. ACC/AHA/NASPE 2002 guideline update for implantation of cardiac pacemakers and antiarrhythmia devices: summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/NASPE Committee to Update the 1998 Pacemaker Guidelines). *Circulation* 2002;106(16):2145–61. [PubMed: 12379588]
3. Twidale N, Sutton K, Bartlett L, Dooley A, Winstanley S, Heddle W, et al. Effects on cardiac performance of atrioventricular node catheter ablation using radiofrequency current for drug-refractory atrial arrhythmias. *Pacing Clin Electrophysiol* 1993;16(6):1275–84. [PubMed: 7686657]
4. Marshall HJ, Harris ZI, Griffith MJ, Gammage MD. Atrioventricular nodal ablation and implantation of mode switching dual chamber pacemakers: effective treatment for drug refractory paroxysmal atrial fibrillation. *Heart* 1998;79(6):543–7. [PubMed: 10078079]
5. Kay GN, Ellenbogen KA, Giudici M, Redfield MM, Jenkins LS, Mianulli M, et al. APT Investigators. The Ablate and Pace Trial: a prospective study of catheter ablation of the AV conduction system and permanent pacemaker implantation for treatment of atrial fibrillation. *J Interv Card Electrophysiol* 1998;2(2):121–35. [PubMed: 9870004]
6. Fitzpatrick AP, Kourouyan HD, Siu A, Lee RJ, Lesh MD, Epstein LM, et al. Quality of life and outcomes after radiofrequency His-bundle catheter ablation and permanent pacemaker implantation: impact of treatment in paroxysmal and established atrial fibrillation. *Am Heart J* 1996;131(3):499–507. [PubMed: 8604629]
7. Shen WK, Hammill SC, Hayes DL, Packer DL, Bailey KR, Ballard DJ, et al. Long-term survival after pacemaker implantation for heart block in patients > or = 65 years. *Am J Cardiol* 1994;74(6):560–4. [PubMed: 8074038]
8. Shen WK, Hayes DL, Hammill SC, Bailey KR, Ballard DJ, Gersh BJ. Survival and functional independence after implantation of a permanent pacemaker in octogenarians and nonagenarians. A population-based study. *Ann Intern Med* 1996;125(6):476–80. [PubMed: 8779460]
9. Melton LJ 3rd. History of the Rochester Epidemiology Project. *Mayo Clin Proc* 1996;71(3):266–74. [PubMed: 8594285]
10. US Census Bureau. Olmsted County QuickFacts from the US Census Bureau. 2006
11. Bower JH, Maraganore DM, McDonnell SK, Rocca WA. Incidence and distribution of parkinsonism in Olmsted County, Minnesota, 1976-1990. *Neurology* 1999;52(6):1214–20. [PubMed: 10214746]

12. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40(5):373–83. [PubMed: 3558716]
13. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol* 1992;45(6):613–9. [PubMed: 1607900]
14. Roger VL, Weston SA, Redfield MM, Hellermann-Homan JP, Killian J, Yawn BP, et al. Trends in heart failure incidence and survival in a community-based population. *Jama* 2004;292(3):344–50. [PubMed: 15265849]
15. Bernstein AD, Parsonnet V. Survey of cardiac pacing and implanted defibrillator practice patterns in the United States in 1997. *Pacing Clin Electrophysiol* 2001;24(5):842–55. [PubMed: 11388104]
16. Sachdev M, Sun JL, Tsiatis AA, Nelson CL, Mark DB, Jollis JG. The prognostic importance of comorbidity for mortality in patients with stable coronary artery disease. *J Am Coll Cardiol* 2004;43(4):576–82. [PubMed: 14975466]
17. Kannel WB, McGee DL. Diabetes and cardiovascular disease. The Framingham study. *Jama* 1979;241(19):2035–8. [PubMed: 430798]
18. Jong P, Vowinkel E, Liu PP, Gong Y, Tu JV. Prognosis and determinants of survival in patients newly hospitalized for heart failure: a population-based study. *Arch Intern Med* 2002;162(15):1689–94. [PubMed: 12153371]
19. Cabell CH, Heidenreich PA, Chu VH, Moore CM, Stryjewski ME, Corey GR, et al. Increasing rates of cardiac device infections among Medicare beneficiaries: 1990-1999. *Am Heart J* 2004;147(4):582–6. [PubMed: 15077071]
20. Voigt A, Shalaby A, Saba S. Rising rates of cardiac rhythm management device infections in the United States: 1996 through 2003. *J Am Coll Cardiol* 2006;48(3):590–1. [PubMed: 16875991]
21. Bernstein AD, Parsonnet V. Survey of cardiac pacing and defibrillation in the United States in 1993. *Am J Cardiol* 1996;78(2):187–96. [PubMed: 8712141]
22. Silverman BG, Gross TP, Kaczmarek RG, Hamilton P, Hamburger S. The epidemiology of pacemaker implantation in the United States. *Public Health Rep* 1995;110(1):42–6. [PubMed: 7838942]
23. Ramirez LF, Thisted R. Using a national health care data base to determine surgical complications in community hospitals: lumbar discectomy as an example. *Neurosurgery* 1989;25(2):218–25. [PubMed: 2770986]
24. Kurland, LT.; Elveback, LR.; Nobrega, FT. Population studies in Rochester and Olmsted County, Minnesota, 1900-1968. In: Kessler, IT.; Levin, ML., editors. *The Community as an Epidemiologic Laboratory: A Case-book of Community Studies*. Johns Hopkins Press; Baltimore: 1970. p. 47-70.
25. Nuttall M, van der Meulen J, Emberton M. Charlson scores based on ICD-10 administrative data were valid in assessing comorbidity in patients undergoing urological cancer surgery. *J Clin Epidemiol* 2006;59(3):265–73. [PubMed: 16488357]
26. Malenka DJ, McLerran D, Roos N, Fisher ES, Wennberg JE. Using administrative data to describe casemix: a comparison with the medical record. *J Clin Epidemiol* 1994;47(9):1027–32. [PubMed: 7730905]
27. Quan H, Parsons GA, Ghali WA. Validity of information on comorbidity derived from ICD-9-CCM administrative data. *Med Care* 2002;40(8):675–85. [PubMed: 12187181]
28. Humphries KH, Rankin JM, Carere RG, Buller CE, Kiely FM, Spinelli JJ. Co-morbidity data in outcomes research: are clinical data derived from administrative databases a reliable alternative to chart review? *J Clin Epidemiol* 2000;53(4):343–9. [PubMed: 10785564]

Figure 1.
PPM implant incidence in Olmsted Co. MN by sex, 1975-2004 (age adjusted to US White, year 2000 population)

PPM Implant Incidence in Olmsted Co. MN by Age Quartile (gender adjusted to US White, year 2000 population)

Figure 2.
PPM implant incidence in Olmsted Co. MN by age, 1975-2004 (sex adjusted to US white, year 2000 population)

Figure 3.
Trends in single versus dual-chamber pacing mode

Figure 4.

Trends in indication for pacemaker placement

SND, Sinus node dysfunction; CSH, carotid sinus hypersensitivity; BCD, bilevel conduction disturbance (sinus node dysfunction plus atrioventricular block); AVB, atrioventricular block. Patients receiving PPM for congestive heart failure or hypertrophic cardiomyopathy (<3% of the total) are not shown.

PPM Cases (n=1128): Survival by Charlson Category

Figure 5.
Survival by Charlson Index Quartile, (n=1128)

Figure 6.

Trends in Charlson Comorbidity Index, Cases vs. Controls, adjusted for age at implant. The p -values above each set of data points represent pairwise comparisons between cases and controls. Intra-group comparisons were analyzed with an age-adjusted ANOVA model. The overall p -value comparing the Charlson Index least squares mean for PPM recipients versus controls was 0.04.

Table 1
Incidence Density (ID) of PPM Implantation in Olmsted County, Minnesota, 1975-2004 (n=1291)

Implant Year	# Implants: Females (ID)*	# Implants: Males (ID)*	Total # Implants	Incidence Density**	Incidence Density Ratio (95% CI)
1975 - 1979	45 (31.8)	34 (42.9)	79	36.6	Reference group
1980 - 1984	75 (47.0)	74 (86.2)	149	61.6	1.68 (1.28, 2.21)
1985 - 1989	90 (49.2)	81 (86.1)	171	62.8	1.70 (1.30, 2.22)
1990 - 1994	108 (51.8)	104 (90.5)	212	67.8	1.86 (1.44, 2.41)
1995 - 1999	138 (62.0)	145 (108.9)	283	80.0	2.17 (1.69, 2.79)
2000 - 2004	214 (85.6)	183 (117.7)	397	99.0	2.73 (2.14, 3.48)

Note: Age groups used for adjustment were: 18-69, 70-79, 80-84, and 85-110.

* Incidence per 100,000 person years directly age-adjusted to the year 2000 U.S. white population.

** Incidence per 100,000 person years directly age- and sex- adjusted to the year 2000 U.S. white population. Confidence intervals based on standard errors via the Poisson distribution. P-value for overall year group effect (Poisson regression adjusting for age and sex) <0.0001.