



# Incidence and mortality of pancreatic cancer on a rapid rise in Taiwan, 1999–2012



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## ABSTRACT

**Background:** Accumulating data has revealed a rapidly rising incidence of pancreatic cancer in Western countries, but convincing evidence from the East remains sparse. We aimed to quantify how the incidence and mortality rates of pancreatic malignancy changed over time in Taiwan, and to develop future projection for the next decade.

**Methods:** This nationwide population-based study analyzed the Taiwan National Cancer Registry and the National Cause of Death Registry to calculate the annual incidence and mortality rates of pancreatic malignancy from 1999 to 2012 in this country. The secular trend of the incidence was also examined by data from the National Health Insurance Research Database.

**Results:** A total of 21,986 incident cases of pancreatic cancer and 20,720 related deaths occurred during the study period. The age-standardized incidence rate increased from 3.7 per 100,000 in 1999 to 5.0 per 100,000 in 2012, with a significant rising trend ( $P < 0.01$ ). The increase was nationwide, consistently across subgroups stratified by age, gender, geographic region, and urbanization. Data from the National Health Insurance Research Database corroborated the rise of incident pancreatic cancer. Mortality also increased with time, with the age-standardized rate rising from 3.5 per 100,000 in 1999 to 4.1 per 100,000 in 2012 ( $P < 0.01$ ). In accordance with the incidence, the mortality trend was consistent in all subgroups. Both the incidence and mortality were projected to further increase by approximately 20% from 2012 to 2027.

**Conclusion:** The incidence and mortality of pancreatic cancer have been rapidly rising and presumably will continue to rise in Taiwan.

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## 1. Introduction

Pancreatic cancer is one of the most aggressive malignancies, and patients have 5-year survival rates of approximately 8% [1]. Worldwide, there were about 337,872 new cases and about 330,372 deaths from pancreatic cancer in 2012. Although pancreatic cancer is the 11th most commonly diagnosed cancer, it is the 7th leading cause of cancer-related deaths worldwide [2,3]. Several factors are responsible for the high death rate from pancreatic cancer. First, there is no cost-effective screening tool [4], and more than 90% of staged cases had locally advanced disease or

**Abbreviation:** AAPC, average annual percent change; BMI, body mass index; NHIRD, National Health Institute Research Database; RCIPI, Registry for Catastrophic Illness Patient Database; TCR, Taiwan Cancer Registry.

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distant metastasis at diagnosis [5]. Second, despite advances in chemotherapy and surgical resection, treatment provided only limited benefit [4]. Third, the incidence of pancreatic cancer continues to increase [6,7]. Ehemann et al. reported that the incidence rate of pancreatic cancer has increased at a rate of 1.4%–1.8% per year from 2004 to 2008 in Western countries [7]. Recent studies in Asian countries reported similar trends [5,8,9]. Although these previous studies show that the threat of pancreatic cancer is rising in many parts of the world [10], few studies have used national registry systems to study the epidemiology of pancreatic cancer.

The universal and compulsory healthcare program in Taiwan allows database analysis at a nationwide scale to examine the incidence and mortality rate of pancreatic cancer. Moreover, this population-based information facilitates unbiased projection of the burden of pancreatic cancer into the near future. We performed this study to evaluate the current trends of incidence and mortality of pancreatic cancer, and used these trends to project its future incidence in Taiwan.

## 2. Materials and methods

### 2.1. Data sources

This nationwide population-based study examined data on pancreatic cancer from the Taiwan Cancer Registry (TCR) database and the Taiwan National Cause of Death Registry (NCDR) database. The TCR was established by the Taiwan government in 1979, and annually publishes the incidence and mortality of all cancers. Hospitals with more than 50 beds in Taiwan are required to report newly diagnosed cancers to the TCR. Previous studies reported the high quality and completeness of these data. In particular, the completeness was 98.4%, the morphological verification percentage was 91.5%, and the percentage of patients with a cancer death certificate without prior enrollment in the TCR was merely 0.7% [11]. In Taiwan, all death certificates issued by doctors are entered into the Taiwan NCDR database. Previous studies showed good accuracy of cause-of-death coding for malignant neoplasms, and the agreement between the reviewer and the coders for malignant neoplasms was excellent ( $\kappa = 0.94$ ) [12]. The National Health Institute Research Database (NHIRD) is the administrative database of the Taiwan Health Insurance program, and covers the health care of more than 99% of the entire population. The Registry for Catastrophic Illness Patient Database (RCIPD) is a subset of the NHIRD. Entry into this registry exempts copayment, and therefore requires explicit criteria for entry, such as imaging or pathological diagnosis [13].

### 2.2. Study participants and outcomes

From 1999 to 2012, we extracted all newly diagnosed and mortality cases of pancreatic cancer from the TCR and the Taiwan NCDR database, based on International Classification of Diseases criteria (ICD-9-157 and ICD-10-C25). Year and age at diagnosis, sex, histology, and area of residence were extracted from the TCR. Year and age at death, sex, and area of residence were extracted from the NCDR database. Each of the 21 counties in Taiwan was classified as rural or urban according to population density, number of physicians per 10,000 people, percentage of people older than 65 years, percentage of people with college education, and percentage of agriculture workers [14].

### 2.3. Data analysis and statistical methods

The annual incidence and mortality rates of pancreatic cancer were calculated by identification of new cases from the TCR

database, and deaths from the Taiwan NCDR database and the number of residents in Taiwan (from the government census). The age-standardized incidence and mortality rates were calculated using the 1960 world standard population, and expressed as cases per 100,000 people. We further stratified the population by sex, age, area of residence, and urbanization of residence, and compared the age-standardized incidence and mortality rates. We adopted the Nordpred software package (R statistical package) [48] for predicting trends in cancer incidence and mortality. The world population in year 2000 was used for age-standardization [15].

## 3. Results

Table 1 shows the baseline characteristics of incident cases and mortality cases from 1999 to 2012. There were 21,968 patients with newly diagnosed pancreatic cancer, 14,408 (59.28%) were male, and 19,290 (87.81%) were more than 50 years-old.

Most cases of pancreatic cancer were recorded in northern Taiwan (45.32%) and urban areas (71.70%). There were 20,720 deaths from pancreatic cancer during the study period, and 12,266 of these patients (59.20%) were male. Similar to the incident cases, most mortality cases were in northern Taiwan (42.05%) and urban areas (68.65%). There were very few incident and mortality cases in eastern Taiwan, because of the small population of this region. Among those with pathological diagnoses, adenocarcinoma was by far the most common histological type ( $n = 13,274$ , 54.62%); 2.42% of these patients ( $n = 588$ ) had neuroendocrine tumors. Pathological diagnosis was unavailable for 10,442 patients (42.96% of all incident cases).

### 3.1. Incidence rate

Fig. 1 shows the change in the age-standardized incidence rate (per 100,000) of pancreatic cancer over time, based on the TCR. The annual incidence rose significantly during the study period, from

**Table 1**  
Baseline characteristic of the pancreatic cancer patients.

	Incidence (N = 21968)		Mortality (N = 20720)	
	N	%	N	%
Gender				
Male	14408	59.28	12266	59.20
Female	9896	40.72	8454	40.80
Age				
≤20	63	0.26	8	0.04
21–30	148	0.61	47	0.23
31–40	657	2.70	379	1.83
41–50	2095	8.62	1491	7.20
51–60	4386	18.05	3275	15.81
61–70	6474	26.64	5277	25.47
>70	10481	43.12	10243	49.44
Area				
Northern	11014	45.32	8713	42.05
Central	5728	23.57	5218	25.18
Southern	6728	27.68	5985	28.89
Eastern	834	3.43	804	3.88
Urbanization				
Urban	17427	71.70	14225	68.65
Rural	6877	28.30	6495	31.35
Histology				
Adenocarcinoma	13274	54.62		
Neuroendocrine tumor	588	2.42		
Others	10442	42.96		

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