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Complete List of Authors:	Maharjan, Urgena; University of Oulu, Faculty of Medicine Kauppila, Joonas H ; Oulu University Hospital, ; Karolinska Institutet,
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Gastric cancer completeness in Finnish Cancer Registry and Finnish Patient Registry, a nationwide study

Authors: Urgena Maharjan[1], Joonas H. Kauppila[1,2]

Affiliations: [1]Surgery Research Unit, Medical Research Center Oulu, Oulu University Hospital and University of Oulu, Oulu, Finland; [2]Upper Gastrointestinal Surgery, Department of Molecular Medicine and Surgery, Karolinska Institutet and Karolinska University Hospital, Stockholm, Sweden.

Corresponding author: Urgena Maharjan, Surgery Research Unit, MRC Oulu, Oulu University Hospital and University of Oulu, P.O. Box 8000, 90014 Oulu
Email: urgena.maharjan@student.oulu.fi

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Keywords: surgery, oncology, gastroenterology, adult gastroenterology, gastrointestinal tumours, public health

Abstract

Background

Gastric cancer is the third leading cause of cancer related deaths worldwide. The only curative treatment of gastric cancer till date is surgical resection. Many nationwide registries have high validity and provide vast range of opportunities for registry-based research. Cancer diagnoses in the Finnish Cancer Registry (FCR) are reported by pathology laboratories and clinician forms, while discharge diagnosis codes are reported to the Finnish Patient Registry (HILMO) automatically. Finland is known for complete registries but the completeness of gastric cancer in FCR and HILMO remains unclear.

Objectives

The aim of this study is to assess the registry coverage for gastric cancer in FCR and HILMO and to explore potential reasons for possible differences between these registries.

Design

Population-based nationwide retrospective cohort study.

Participants

All patients diagnosed with gastric cancer in Finland during 1990 to 2014, with follow- up until December 31, 2019.

Results

Out of 21,468 total gastric cancers reported to either registry, 17,107 (79.7%) had a gastric cancer diagnosis in both registries. The completeness of FCR was estimated at 87%. For HILMO, the completeness was 92.7%. Death due to gastric cancer was most common in those with gastric cancer in both registries (80.8%), and less common in those reported to only FCR (36.3%), followed by those reported to only HILMO (9.3%).

Conclusions

The study indicates that gastric cancer is well captured by both FCR and HILMO but there is an alarming decrease in the proportion of cases captured by the Finnish Cancer Registry over time. Some gastric cancer diagnoses in HILMO might, however, be misclassified due to cancer diagnoses being assigned based on clinical suspicion.

Article Summary

Strengths and limitations of this study:

- The main strength of this study is the population- based nationwide design.
- The size of the cohort was large with a complete follow-up of all patients diagnosed with gastric cancer in Finland.
- The population-based design of this study and complete follow-up of participants counteracts any selection-bias.
- The limitation of the study is the unavailability of medical records for the assessment of validity of diagnoses.

Funding statement:

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Competing interests statement: The authors state no potential competing interests.

Author contributions:

Concept and design: UM, JHK; Obtained funding; JHK; Statistical analysis: JHK; Interpretation: UM, JHK; Drafted the manuscript: UM; Critical revision for intellectual content and accepted submitted version JHK; Guarantor: JHK.

Data sharing statement:

All data presented in this article are available from THL/Findata, Finland. Data access to collaborators can be granted given that relevant government and health officials approve the collaborative study.

Introduction

Gastric cancer is declining in incidence but remains the third leading cause of cancer-related death around the world [1]. Gastric cancers are anatomically classified into non-cardia (true gastric adenocarcinomas) and cardia (gastro-esophageal junction adenocarcinomas) [2]. *Helicobacter pylori* infection is a major risk factor of gastric cancer [3]. Prevention of colonization of *H. pylori* has shown potential in reduction of the incidences of gastric cancer. Other preventive measures could include changes in diet, reducing smoking and alcohol-intake and adequate physical activity [4]. The only curative treatment option of gastric cancer is surgical resection [5].

The nationwide Nordic registries with high validity provide opportunities for registry-based medical research and cohort studies with long and complete follow-up [6]. Although Finland is known for complete and accurate registries [7, 8], the completeness of gastric cancer diagnosis in Finnish Cancer Registry (FCR) and Finnish Patient Registry (HILMO) is still unclear. Therefore, the quality of these registries must be evaluated for their proper utilization in future research.

The aim of this study is to assess the registry coverage for gastric cancer in FCR and HILMO and to explore potential reasons for possible differences between registries.

Methods

Study design

A population-based, retrospective cohort study of all gastric cancer patients in Finland during 1990-2014 was conducted. This study was approved by the Northern Ostrobothnia ethical committee (EETMK 115/2016). Informed consent was not required [9,10].

Data sources

The data on gastric cancer was retrieved from Finnish Cancer registry (FCR) and Finnish Patient Registry (HILMO). All the patients who had gastric cancer in either FCR or HILMO were identified using respective ICD-9 (151) and ICD-10 (C16) codes. Mortality was evaluated from the death registry held by Statistics Finland. Unique immutable personal identification number assigned to all residents in Finland were used to combine registry data.

The Finnish cancer registry (FCR) and patient registry (HILMO) are comprehensive registries as all healthcare units in Finland are obligated to enter patient and treatment data into these registries. The FCR includes all incident cancers from the population of Finland since the year 1953. These data are usually input by clinicians by using electronical forms and semi-automatically reported from laboratories. The FCR collects information on cancer type, date of diagnosis, location of cancer and treatment information [7]. The Finnish patient registry (HILMO) on the other hand, includes information on discharge dates, diagnosis and operation codes assigned to every patient on admission. The hospital administration reports the discharge information into the patient registry [8].

Statistics Finland death registry provides information on patient death, date of death and its primary and secondary causes. Death information is input by clinicians into the death certificates which include description of patients' disease and cause of death based on evaluation or autopsies [11]. The correctness of all death certificates is checked by forensic physicians before they are recorded in Statistics Finland causes of death. The completeness of the registry is 100% for date of death and >99% for cause of death [12].

Statistical analysis

The data was retrieved from the FCR and HILMO registries from the period of 1987-2016. Cancer diagnoses during the first three years were excluded to reliably identify the earliest cancer incidence and the last two years were omitted due to potential time lag in reporting, resulting in time period of 25 years from 1990 to 2014. Patients diagnosed only in autopsies were excluded. Death data was available until 2019, resulting in a minimum follow-up of 5 years for all patients.

For analysis of completeness, the three sub-populations were derived from the total cohort: 1) those present in FCR only 2) those present in HILMO only and 3) those present in both FCR and HILMO. The proportions of patients in these three groups were calculated in total and stratified in terms of sex, age, calendar period, surgery, causes of death and gastric cancer records in HILMO and FCR. The death registry was used to identify those who died of gastric cancer. Survival analysis was conducted with life table method [13] and plotted using Kaplan-Meier curves.

Permissions and registration

The study has been approved by ethical committee in Northern Osthrobothnia (EETMK 115/2016), The National Institute for Health and Welfare (THL/169/5.05.00), Statistics Finland (TK-53-1478-17) and the Office of the Data Protection Ombudsman (Dnro 506/402/17), Finland. Individual informed consent was not sought from the patients, as obtaining the informed consent was waived by the Finnish law. The study was conducted in accordance with the Declaration of Helsinki.

Patient and public involvement

Patients or public were not involved in the development of the research question and study design or conducting the present study.

Results

Patients

There was a total of 21,468 gastric cancers reported in either registry of FCR and HILMO during the 25 years. Among these cases 17,107 (79.7%) were reported to both FCR and HILMO, 1,561 (7.3%) were reported only to FCR and 2,800 (13.0%) were reported only to HILMO (Table 1). Based on these numbers, FCR captured 87.0% of gastric cancers, and HILMO captured 92.7% of gastric cancers.

Of the total cases, 11,760 (54.8%) were male and 9,708 (45.2%) were female. The median age for diagnosis was 70 years. The highest number of patients were observed during the period of 1990-1994 which was 5,240 (24.4%). Surgical treatment was received by 8,860 (41.3%) of total patients. No major differences were observed in the reporting to the registries in terms of sex and age group. Surgically treated patients were more often reported to both registries than those without surgery. A considerable decrease from 88.3% in 1990-1994 to 83.4% in 2010-2014 was observed in the proportion of cases reported to FCR over time (Table 1).

Of all patients (19,397) who died, 14,656 (75.6%) died of gastric cancer and 4,741 (24.4%) died of other causes. The majority of deaths were observed in those reported to both FCR and HILMO (Table 1).

Patients reported in FCR only

Of 1,561 patients who were reported to FCR only, 566 (36.3%) died of gastric cancer, 634 (40.6%) died of other causes and the rest 361 (23.1%) were still alive (Table 1). No esophageal cancer diagnosis was recorded in HILMO for 1,311 (84.0%), suggesting low misclassification. Admissions for esophageal cancers were recorded in 250 (16.0%) patients, but only 6 (0.4%) had esophageal cancer recorded in FCR (Table 2).

Patients reported in HILMO only

Of 2,800 patients who were reported to HILMO only, 259 (9.3%) died of gastric cancer, 2,101 (75.0%) died of other causes, leaving 440 (15.7%) alive (Table 1). Admissions for esophageal cancers were recorded in 425 (15.2%) patients, and esophageal cancer was recorded in FCR for 437 (15.6%) of the patients (Table 2).

Patients reported in both

Of 17,107 patients reported to both FCR and HILMO (Table 1), 13,831 (80.8%) died of gastric cancer, 2,006 (11.7%) died of other causes and the rest 1,270 (7.4%) were still alive (Table 1). The majority (85.6%) had two or more gastric cancer admissions and no admission for esophageal cancer (95.5%, Table 2).

Mortality

Those who were reported to only HILMO, or only FCR had lower mortality than those who were reported to both FCR and HILMO (Figure 1).

Discussion

The study shows that gastric cancer is well captured by both FCR and HILMO registries but there is an alarming decrease in the proportion of cases captured by FCR over time.

Some of the strengths of the study include the population- based nationwide design and a large size of cohort with a complete follow-up of all patients diagnosed with gastric cancer in Finland preventing any selection-bias. A weakness of the study is the unavailability of medical records for the assessment of validity of diagnoses.

The proportions of gastric cancer reported to FCR, HILMO and both were relatively similar between sex and age groups. Surgical patients were more often reported to both FCR and HILMO, suggesting that palliative and/or patients not undergoing surgical resection might be more often missed by either of these registries. A significant decline in reporting to FCR was observed over time. As reporting to HILMO is based on administration, but FCR relies on reporting by physicians, physician workload and lack of clarity in responsibilities of reporting might influence this phenomenon. Even though reporting to FCR is mandated by legislation, it might be that physicians do not see reporting new cancer cases to FCR as important part of cancer treatment. Even though the laboratories automatically report these cases to the FCR, some diagnoses might still be missed. Lastly, some malignant tumors of lower malignancy grade, such as gastric neuroendocrine tumors might be more likely to be missed by cancer registry, as suggested by better survival in those patients only reported to FCR compared to being reported to both registries.

Based on high gastric cancer mortality, the specificity of gastric cancer diagnoses was high in those reported to both registries. The FCR might have a higher specificity of cancer diagnoses in comparison to HILMO. This is reflected by slightly higher proportion of gastric cancer deaths reported to only FCR compared to those reported to only HILMO. Furthermore, half of those patients not reported to only HILMO had only one gastric cancer admission in HILMO, while the other half had two or more admissions, potentially reflecting cases where cancer diagnosis was assigned to a patient during evaluation for suspected cancer, but this diagnosis was then not confirmed later.

The survival curves showed that the mortality was lower in those reported to only HILMO and those reported to only FCR, compared to those reported to both, suggesting that some misclassification or lower malignancy tumors are included in patients not reported to both registries. Previously reported misclassification between esophageal and gastric (cardia) cancer was low based on causes of death and esophageal cancer admissions [14].

The estimated completeness was 87.0% for FCR and 92.7% for HILMO. Based on these figures, both registries can be reliably used for registry research in gastric cancer. To turn the decreasing trend of reporting to FCR, clinicians are recommended to report all gastric cancer patients to FCR at all stages of diagnosis and treatment. Automatic reporting to FCR during the assignment of cancer diagnosis to a patient in the electronic medical records could help improve the declining trend.

In conclusion, both FCR and HILMO have high completeness and validity in gastric cancer diagnoses. Clinicians are suggested to pay attention to reporting all new cases to FCR, and to

consider not assigning cancer diagnoses during initial diagnostic workup to reduce potential false positives in the registries.

Funding

This study was supported by research grants from the Sigrid Jusélius Foundation (Sigrid Juséliuksen Säätiö), The Finnish Cancer Foundation (Syöpäsäätiö) and Päivikki and Sakari Sohlberg Foundation.

References

[1] Global Burden of Disease Cancer Collaboration. Global, Regional, and National Cancer Incidence, Mortality, Years of Life Lost, Years Lived With Disability, and Disability-Adjusted Life-Years for 29 Cancer Groups, 1990 to 2017: A Systematic Analysis for the Global Burden of Disease Study. JAMA Oncol. 2019;5(12):1749–1768.

[2] Hu B, El Hajj N, Sittler S, Lammert N, Barnes R, Meloni-Ehrig A. Gastric cancer: Classification, histology and application of molecular pathology. J Gastrointest Oncol. 2012;3(3):251-261.

[3] Machlowska J, Baj J, Sitarz M, Maciejewski R, Sitarz R. Gastric cancer: Epidemiology, risk factors, classification, genomic characteristics and treatment strategies. Int J Mol Sci. 2020;21(11):4012

[4] den Hoed CM, Kuipers EJ. Gastric cancer: How can we reduce the incidence of this disease? Curr Gastroenterol Rep. 2016;18(7):34-0.

[5] Smyth EC, Nilsson M, Grabsch HI, van Grieken NC, Lordick F. Gastric cancer. Lancet. 2020 Aug 29;396(10251):635-648.

[6] Maret-Ouda J, Tao W, Wahlin K, Lagergren J. Nordic registry-based cohort studies: Possibilities and pitfalls when combining nordic registry data. Scand J Public Health. 2017;45(17_suppl):14-19.

[7] Leinonen MK, Miettinen J, Heikkinen S, et al. Quality measures of the population-based Finnish Cancer Registry indicate sound data quality for solid malignant tumours. Eur J Cancer. 2017 May; 77:31-39.

[8] Sund R. Quality of the Finnish Hospital Discharge Register: a systematic review. Scand J Public Health. 2012 Aug;40(6):505-15.

[9] Kauppila JH, Ohtonen P, Karttunen TJ, et al. Finnish National Esophago- Gastric Cancer Cohort (FINEGO) for studying outcomes after oesophageal and gastric cancer surgery: a protocol for a retrospective, population-based, nationwide cohort study in Finland. BMJ Open. 2019 Jan 15;9(1): e024094.

[10] Kauppila JH, Ohtonen P, Rantanen T, et al. Cohort profile: Gastric cancer in the population-based, finnish national esophago-gastric cancer cohort (FINEGO) study. BMJ Open. 2020;10(10):e039574.

[11] Lahti RA, Penttilä A. The validity of death certificates: Routine validation of death certification and its effects on mortality statistics. Forensic Sci Int. 2001;115(1-2):15-32.

[12] Official Statistics of Finland (OSF): Quality Description: Causes of death 2018 [internet]. Helsinki: Statistics Finland; 2018 [cited date: 2020-01-27]. Available from: http://www.stat.fi/til/ksyyt/2018/ksyyt_2018_2019-12-16_laa_001_en.html.

[13] Cutler SJ, Ederer F. Maximum utilization of the life table method in analysing survival. J Chronic Dis. 1958 Dec;8(6):699-712.

[14] Kauppila JH. Completeness of esophageal cancer diagnosis in the Finnish Cancer Registry and hospital discharge registry, a nationwide study in Finland. Acta Oncol. 2020 Nov;59(11):1329-1332.

Table 1. The characteristics and vital status with causes of death in gastric cancer patients reported to Finnish Cancer Registry (FCR) and Hospital Discharge Registry (HILMO)

Variable	FCR only n (%)	HILMO only n (%)	Both FCR and HILMO n (%)	Total n (%)
Total	1561 (7.3)	2800 (13.0)	17107 (79.7)	21468 (100)
Sex				
Female	801 (8.3)	1271 (13.1)	7636 (78.7)	9708 (100)
Male	760 (6.5)	1529 (13.0)	9471 (80.5)	11760 (100)
Age at diagnosis				
Up to 50 years	150 (8.3)	212 (11.7)	1452 (80.0)	1814 (100)
51-60 years	237 (7.8)	417 (13.8)	2367 (78.4)	3021 (100)
61-70 years	344 (6.7)	732 (14.2)	4087 (79.2)	5163 (100)
71-80 years	383 (5.7)	891 (13.3)	5431 (81.0)	6705 (100)
81-90 years	363 (8.4)	508 (11.8)	3429 (79.7)	4300 (100)
Over 90 years	84 (18.1)	40 (8.6)	341 (73.3)	465 (100)
Surgery				
No	1281 (10.2)	2200 (17.4)	9127 (72.4)	12608 (100)
Yes	280 (3.2)	600 (6.8)	7980 (90.1)	8860 (100)
Time period				
1990-1994	385 (7.3)	613 (11.7)	4242 (81.0)	5240 (100)
1995-1999	318 (7.1)	438 (9.8)	3729 (83.1)	4485 (100)
2000-2004	280 (6.7)	570 (13.6)	3345 (79.7)	4195 (100)
2005-2009	271 (6.9)	573 (14.7)	3059 (78.4)	3903 (100)
2010-2014	307 (8.4)	606 (16.6)	2732 (75.0)	3645 (100)
Vital status*				
Alive	361 (23.1)	440 (15.7)	1270 (7.4)	2071 (9.6)
Dead	1200 (76.9)	2360 (84.3)	15837 (92.6)	19397 (90.4)
Cause of death**				
Gastric cancer	566 (47.2)	259 (11.0)	13831 (87.3)	14656 (75.6)
Other	634 (52.8)	2101 (89.0)	2006 (12.7)	4741 (24.4)

FCR: Finnish Cancer Registry; HILMO: Hospital Discharge Registry.

*Calculated as the percentage of total patients in each group

**Calculated as the percentage of those who died

Table 2. The number of admissions for esophageal cancer and gastric cancer in Hospital Discharge Registry (HILMO), and esophageal cancer diagnoses in the Finnish Cancer Registry (FCR) in gastric cancer patients.

Variable	FCR only n (%)	HILMO only n (%)	Both FCR and HILMO n (%)	Total n (%)
Total	1561 (100)	2800 (100)	17107 (100)	21468 (100)
Number of gastric cancer admissions in HILMO				
0	1561 (100)	-	-	1561 (7.3)
1	-	1470 (52.5)	2465 (14.4)	3935 (18.3)
2 or more	-	1330 (47.5)	14642 (85.6)	15972 (74.4)
Number of esophageal cancer admissions in HILMO				
0	1311 (84.0)	2375 (84.8)	16343 (95.5)	20029 (93.3)
1	27 (1.7)	47 (1.7)	266 (1.6)	340 (1.6)
2 or more	223 (14.3)	378 (13.5)	498 (2.9)	1099 (5.1)
Esophageal cancer diagnosis in gastric cancer patients in FCR				
No	1555 (99.6)	2363 (84.4)	17091 (99.9)	21009 (97.9)
Yes	6 (0.4)	437 (15.6)	16 (0.1)	459 (2.1)

FCR: Finnish Cancer Registry; HILMO: Hospital Discharge Registry.

Figure caption:

Figure 1. Kaplan-Meier curve depicting 5-year all-cause mortality in gastric cancer patients stratified by registry status. The red line represents those in FCR only, the blue line represents those patients registered in HILMO only, and the green line represents those in both FCR and HILMO.

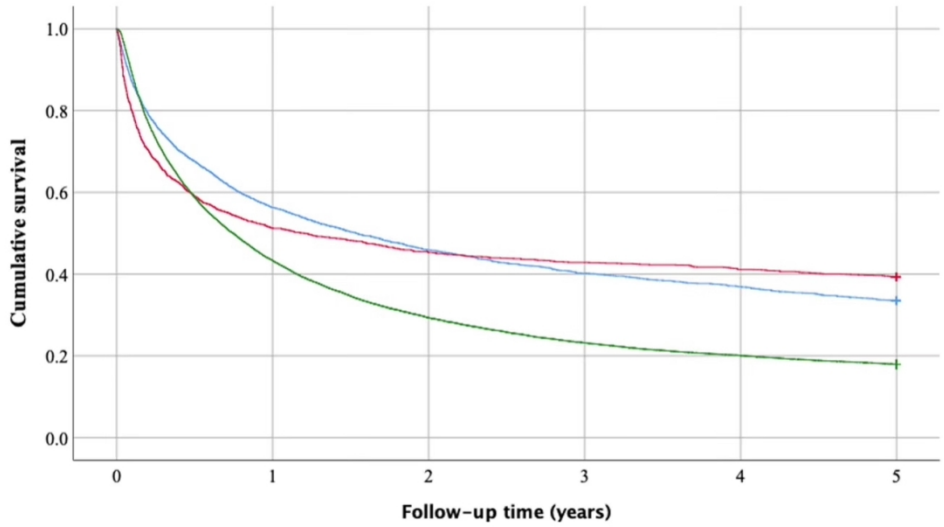

Figure 1. Kaplan-Meier curve depicting 5-year all-cause mortality in gastric cancer patients stratified by registry status. The red line represents those in FCR only, the blue line represents those patients registered in HILMO only, and the green line represents those in both FCR and HILMO.

117x64mm (300 x 300 DPI)

Study protocol

Project title: Gastric cancer completeness in Finnish Cancer Registry and Finnish Patient Registry, a nationwide study

Collaborators: Urgena Maharjan[1], Joonas H. Kauppila[1,2]

Affiliations: [1]Surgery Research Unit, Medical Research Center Oulu, Oulu University Hospital and University of Oulu, Oulu, Finland; [2]Upper Gastrointestinal Surgery, Department of Molecular Medicine and Surgery, Karolinska Institutet and Karolinska University Hospital, Stockholm, Sweden.

1. Introduction

Gastric cancer is the fourth most common and the second leading cause of cancer-related death around the world. Two types of anatomically classified gastric cancers are commonly seen: non- cardia or true gastric adenocarcinomas and cardia or gastro-esophageal- junction adenocarcinomas. Histologically gastric cancers are divided into diffuse and intestinal types. Only curative measure of gastric cancer till date is surgery [1]. Although the incidences of gastric cancer have decreased sharply in Finland over the years due to improved quality of life, it remains one of the most diagnosed diseases in Finland.

Although Finland is known for complete and accurate registries, the completeness of gastric cancer diagnosis in Finnish Cancer Registry (FCR) and Finnish Patient Registry (HILMO) is still quite unclear. A study has shown a misclassification between gastric and esophageal cancers. For example, distal esophageal and gastric cardia cancers are often misclassified due to their similar anatomical locations [2]. Therefore, the quality of these registries must be audited to utilize them in various further research.

2. Aims of research

The aim of this study is to assess the registry coverage for gastric cancer comparing FCR and HILMO and the death registry, detect any potential misclassifications between gastric and esophageal cancers and thus evaluate the completeness of gastric cancer diagnoses in FCR and HILMO.

3. Methods

Study design

The research is a population-based, nationwide, retrospective cohort study of all gastric cancer patients identified in Finland. The data regarding gastric cancer incidence will be accessed from Finnish Cancer registry (FCR) and Finnish Patient Registry (HILMO). All the patients who had gastric cancer in FCR or HILMO will be included. Mortality will be evaluated from the death registry. Personal identification number assigned to all residents in Finland will be used to combine registry data.

Data analysis

The data will be retrieved from the FCR and HILMO registries from the period 1987-2016. For the comparison of their completeness, three sub-populations will be derived from the total cohort: 1) those present in FCR only 2) those present in HILMO only and 3) those present in both FCR and HILMO. The proportions of patients in these three groups will be calculated in total and stratified in terms of sex, age, calendar period, surgery, causes of death and gastric cancer records in HILMO and FCR. The death registry will be used to identify those who died of gastric cancer. Survival analysis will be conducted with life table method and plotted using Kaplan-Meier curves. Coverage in surgical and non-surgical patients will be evaluated.

4. Impact

The study will help us discover any incidents of misclassification between gastric and esophageal cancer. The findings will thus help in any further research on gastric cancer and provide information on its proper management. The strength of the research is its population-based nationwide design with a large size of cohort and a complete follow-up. However, unavailability of the medical records might affect the assessment of the validity of the diagnoses.

References

[1] Van Cutsem, E., Sagaert, X., Topal, B., Haustermans, K., & Prenen, H. (2016). Gastric cancer. Lancet (London, England), 388(10060), 2654–2664.

[2] Kauppila JH. Completeness of esophageal cancer diagnosis in the Finnish Cancer Registry and hospital discharge registry, a nationwide study in Finland. Acta Oncol. 2020 Nov;59(11):1329-1332.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*6*
Bias	9	Describe any efforts to address potential sources of bias	n/a
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	n/a
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9, 15
		(b) Indicate number of participants with missing data for each variable of interest	15
		(c) Summarise follow-up time (eg, average and total amount)	7
Outcome data	15*	Report numbers of outcome events or summary measures over time	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Gastric cancer completeness in Finnish Cancer Registry and Finnish Patient Registry, a population-based nationwide retrospective cohort study

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Gastric cancer completeness in Finnish Cancer Registry and Finnish Patient Registry, a population-based nationwide retrospective cohort study

Authors: Urgena Maharjan[1], Joonas H. Kauppila[1,2]

Affiliations: [1]Surgery Research Unit, Medical Research Center Oulu, Oulu University Hospital and University of Oulu, Oulu, Finland; [2]Upper Gastrointestinal Surgery, Department of Molecular Medicine and Surgery, Karolinska Institutet and Karolinska University Hospital, Stockholm, Sweden.

Corresponding author: Urgena Maharjan, Surgery Research Unit, MRC Oulu, Oulu University Hospital and University of Oulu, P.O. Box 8000, 90014 Oulu
Email: urgena.maharjan@oulu.fi

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Abstract

Background: Gastric cancer is the fourth leading cause of cancer related deaths worldwide. The only curative treatment options of gastric cancer are perioperative chemotherapy and surgical resection. Many nationwide registries have high validity and provide vast range of opportunities for registry-based research. Cancer diagnoses in the Finnish Cancer Registry (FCR) are reported by pathology laboratories and clinician forms, while discharge diagnosis codes are reported to the Finnish Patient Registry (HILMO) automatically. Finland is known for complete registries but the completeness of gastric cancer in FCR and HILMO remains unclear.

Objectives: The aim of this study is to assess the registry coverage for gastric cancer in FCR and HILMO and to explore potential reasons for possible differences between these registries.

Design: Population-based nationwide retrospective cohort study.

Participants: All patients diagnosed with gastric cancer in Finland during 1990 to 2014, with follow- up until December 31, 2019.

Results: Out of 21,468 total gastric cancers reported to either registry, 17,107 (79.7%) had a gastric cancer diagnosis in both registries. A substantial decrease from 88.3% to 83.4% was observed in the proportion of cases reported to FCR over time. The completeness of FCR was estimated at 87%. For HILMO, the completeness was 92.7%. Death due to gastric cancer was most common in those with gastric cancer in both registries (80.8%), and less common in those reported to only FCR (36.3%), followed by those reported to only HILMO (9.3%).

Conclusions: The study indicates that gastric cancer is well captured by both FCR and HILMO but there is an alarming decrease in the proportion of cases captured by the Finnish Cancer Registry over time. Some gastric cancer diagnoses in HILMO might, however, be misclassified due to cancer diagnoses being assigned based on clinical suspicion.

Article Summary

Strengths and limitations of this study:

- The main strength of this study is the population- based nationwide design.
- The size of the cohort was large with a complete follow-up of all patients diagnosed with gastric cancer in Finland.
- The population-based design of this study and complete follow-up of participants counteracts any selection-bias.
- The limitation of the study is the unavailability of medical records for the assessment of validity of diagnoses.

Funding statement:

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Author contributions:

Concept and design: UM, JHK; Obtained funding; JHK; Statistical analysis: JHK; Interpretation: UM, JHK; Drafted the manuscript: UM; Critical revision for intellectual content and accepted submitted version JHK; Guarantor: JHK.

Data sharing statement:

All data presented in this article are available from THL/Findata, Finland. Data access to collaborators can be granted given that relevant government and health officials approve the collaborative study.

Introduction

Gastric cancer is declining in incidence but remains the fourth leading cause of cancer-related death around the world [1]. Gastric cancers are anatomically classified into gastric cardia cancer, including Siewert type II cancer and gastric non-cardia cancer, including true gastric adenocarcinomas and Siewert type III cancer [2-4]. Currently the only curative treatment of gastric adenocarcinoma, the most prevalent gastric cancer, is surgical resection with or without perioperative chemotherapy [5].

The nationwide Nordic registries with high validity provide opportunities for registry-based medical research and cohort studies with long and complete follow-up [6]. Finland is known for complete and accurate registries e.g., the Finnish Cancer Registry (FCR) reporting cancer statistics, and the Finnish Patient Registry (HILMO) collecting hospital discharge diagnoses and surgical codes for statistical and governmental purposes [7, 8]. The completeness of gastric cancer diagnosis in FCR and HILMO is, nonetheless, still unclear. Therefore, the quality of these registries must be evaluated for their proper utilization in future research.

The aim of this study is to assess the registry coverage for gastric cancer in FCR and HILMO and to explore potential reasons for possible differences between registries.

Methods

Study design

A population-based nationwide retrospective cohort study of all gastric cancer patients in Finland during 1990-2014 was conducted. This study was approved by the Northern Ostrobothnia ethical committee (EETMK 115/2016). Informed consent was not required [9,10].

Data sources

The data on gastric cancer was retrieved from the Finnish Cancer registry (FCR) and the Finnish Patient Registry (HILMO). All the patients who had gastric cancer in either FCR or HILMO were identified using respective ICD-9 (151) and ICD-10 (C16) codes. Mortality was evaluated from the death registry held by Statistics Finland. Unique immutable personal identification number assigned to all residents in Finland were used to combine registry data.

The Finnish cancer registry (FCR) and patient registry (HILMO) are comprehensive registries as all healthcare units in Finland are obligated to enter patient and treatment data into these registries. FCR includes all incident cancers from the population of Finland since the year 1953. These data are usually input by clinicians by using paper-, and more recently electronical forms and semi-automatic reporting of cancer from pathology and cytology laboratories. FCR collects information on cancer type, date of diagnosis, location of cancer from laboratory notifications and treatment information from both clinical and laboratory notifications [7]. However, as these notifications are based on histological or cytological confirmation, or a form filled by a

clinician, some cancers many be missed. HILMO on the other hand, is completely independent from FCR and includes information on discharge dates, diagnosis and operation codes assigned by clinicians to every patient during each admission. The hospital administration reports these codes electronically and automatically into the patient registry on discharge. Reimbursements from the municipalities are based on these same diagnosis and operation codes. Furthermore, these discharge codes are used by governmental bodies to calculate the healthcare district and municipality-specific rates of healthcare costs and morbidity indices, that serve as the basis of healthcare funding to the municipalities and hospital districts from the government. More than 99% of hospital discharges are reports to HILMO [8].

Statistics Finland death registry provides information on patient death, date of death and its primary and secondary causes. Death information is input by clinicians into the death certificates which include description of patients' disease and cause of death based on evaluation or autopsies [11]. The correctness of all death certificates is checked by forensic physicians before they are recorded in Statistics Finland causes of death. The completeness of the registry is 100% for date of death and >99% for cause of death [12].

Statistical analysis

The data was retrieved from FCR and HILMO from the period of 1987-2016. Cancer diagnoses during the first three years were excluded to reliably identify the earliest cancer incidence and the last two years were omitted due to potential time lag in reporting, resulting in time period of 25 years from 1990 to 2014. Patients diagnosed only in autopsies were excluded. Death data was available until 2019, resulting in a minimum follow-up of 5 years for all patients.

For analysis of completeness, the three sub-populations were derived from the total cohort: 1) those present in FCR only 2) those present in HILMO only and 3) those present in both FCR and HILMO. The proportions of patients in these three groups were calculated in total and stratified in terms of sex, age, calendar period, surgery, causes of death and gastric cancer records in HILMO and FCR. The death registry was used to identify those who died of gastric cancer. Survival analysis was conducted to examine the mortality patterns in the different groups with life table method [13] and plotted using Kaplan-Meier curves to indirectly evaluate whether there were major differences in the accuracy of gastric cancer recording, as these cancers are known to have high mortality.

Permissions and registration

The study has been approved by ethical committee in Northern Osthrobothnia (EETMK 115/2016), The National Institute for Health and Welfare (THL/169/5.05.00), Statistics Finland (TK-53-1478-17) and the Office of the Data Protection Ombudsman (Dnro 506/402/17), Finland. Individual informed consent was not sought from the patients, as obtaining the informed consent was waived by the Finnish law. The study was conducted in accordance with the Declaration of Helsinki.

Patient and public involvement

Patients or public were not involved in the development of the research question and study design or conducting the present study.

Results

Patients

Of the total 22,121 gastric cancers diagnosed in 1990-2014, 19,907 had a gastric cancer diagnosis in HILMO, and 19,321 in FCR. Considering all patients with gastric cancer in the FCR, the Death Certificate Only (DCO) rate was 1.4% (n=268). Of those with gastric cancer diagnosis only in FCR, 653 were diagnosed during autopsy were excluded from further analyses.

After exclusion, there was a total of 21,468 gastric cancers reported in either registry of FCR and HILMO during the 25 years. Among these cases 17,107 (79.7%) were reported to both FCR and HILMO, 1,561 (7.3%) were reported only to FCR and 2,800 (13.0%) were reported only to HILMO (Table 1). Based on these numbers, FCR captured 87.0% of gastric cancers, and HILMO captured 92.7% of gastric cancers.

Of the total cases, 11,760 (54.8%) were male and 9,708 (45.2%) were female. The median age for diagnosis was 70 years. The highest number of patients were observed during the period of 1990-1994 which was 5,240 (24.4%). Surgical treatment was received by 8,860 (41.3%) of total patients. No major differences were observed in the reporting to the registries in terms of sex and age group. Surgically treated patients were more often reported to both registries than those without surgery. A considerable decrease from 88.3% in 1990-1994 to 83.4% in 2010-2014 was observed in the proportion of cases reported to FCR over time (Table 1).

Of all patients (19,397) who died, 14,656 (75.6%) died of gastric cancer and 4,741 (24.4%) died of other causes. A majority of deaths were observed in those reported to both FCR and HILMO (Table 1).

Patients reported in FCR only

Of 1,561 patients who were reported to FCR only, 566 (36.3%) died of gastric cancer, 634 (40.6%) died of other causes and the rest 361 (23.1%) were still alive (Table 1). No esophageal cancer diagnosis was recorded in HILMO for 1,311 (84.0%), suggesting low misclassification. Admissions for esophageal cancers were recorded in 250 (16.0%) patients, but only 6 (0.4%) had esophageal cancer recorded in FCR (Table 2).

Patients reported in HILMO only

Of 2,800 patients who were reported to HILMO only, 259 (9.3%) died of gastric cancer, 2,101 (75.0%) died of other causes, leaving 440 (15.7%) alive (Table 1). Admissions for esophageal cancers were recorded in 425 (15.2%) patients, and esophageal cancer was recorded in FCR for 437 (15.6%) of the patients (Table 2).

Patients reported in both

Of 17,107 patients reported to both FCR and HILMO (Table 1), 13,831 (80.8%) died of gastric cancer, 2,006 (11.7%) died of other causes and the rest 1,270 (7.4%) were still alive (Table 1). A majority (85.6%) had two or more gastric cancer admissions and no admission for esophageal cancer (95.5%, Table 2).

Mortality

As gastric cancer is known to have high mortality rate, survival analysis was conducted to further evaluate the accuracy of gastric cancer diagnoses in each of the groups. The 5- year mortality in all groups were high. Those who were reported to only HILMO, or only FCR had lower mortality than those who were reported to both FCR and HILMO (Figure 1).

Discussion

The study shows that gastric cancer is well captured by both FCR and HILMO registries but there is an alarming decrease in the proportion of cases captured by FCR over time.

Some of the strengths of the study include the population- based nationwide design and a large size of cohort with a complete follow-up of all patients diagnosed with gastric cancer in Finland preventing any selection-bias. A weakness of the study is the unavailability of medical records for the assessment of validity of diagnoses.

The proportions of gastric cancer reported to FCR, HILMO and both were relatively similar between sex and age groups. Surgical patients were more often reported to both FCR and HILMO, suggesting that palliative and/or patients not undergoing surgical resection might be more often missed by either of these registries. A significant decline in reporting to FCR was observed over time. As reporting to HILMO is based on administration, but FCR relies on reporting by physicians, physician workload and lack of clarity in responsibilities of reporting might influence this phenomenon. Even though reporting to FCR is mandated by legislation, it might be that physicians do not see reporting new cancer cases to FCR as important part of cancer treatment, or that reporting is missed due to lack of impact on the treatment of the patient. Even though the laboratories automatically report these cases to the FCR, some diagnoses in which histological confirmation is not sought, might still be missed. Lastly, some malignant tumors of lower malignancy grade, such as gastric neuroendocrine tumors might be more likely to be missed by cancer registry, as suggested by better survival in those patients only reported to FCR compared to being reported to both registries.

Gastric cancer is associated with high mortality. FCR might have a higher specificity of cancer diagnoses in comparison to HILMO, reflected by slightly higher proportion of gastric cancer deaths reported to only FCR compared to those reported to only HILMO. Furthermore, half of those patients not reported to only HILMO had only one gastric cancer admission in HILMO, while the other half had two or more admissions, potentially reflecting cases where cancer diagnosis was assigned to a patient during evaluation for suspected cancer, but this diagnosis was then not confirmed later. In survival analysis, mortality in all groups was high, supporting the view that the specificity of gastric cancer diagnoses was relatively high in also those missed by either FCR or HILMO. The survival curves showed that the mortality was lower in those reported to only HILMO and those reported to only FCR, compared to those reported to both, suggesting that some misclassification or lower malignancy tumors might be included in patients not reported to both registries. Previously reported possible misclassification between distal esophageal and gastric (cardia) cancer [14] was deemed low based on the low number of esophageal cancer deaths and esophageal cancer admissions in this cohort of gastric cancer patients.

The estimated completeness of gastric cancer was 87.0% for FCR and 92.7% for HILMO. Previously, both FCR and HILMO have shown to have above 90% completeness for esophageal cancer [14]. A good accuracy of FCR was also indicated by a similar study for colorectal cancer [15]. A Swedish study, on the other hand, indicated a substantial underreporting of pancreatic and biliary cancers in the Swedish Cancer Registry [16]. Based on these figures, both FCR and HILMO can be reliably used for registry research in gastric cancer. To turn the decreasing trend of reporting to FCR, clinicians are recommended to report all gastric cancer patients to FCR at all stages of diagnosis and treatment. Automatic reporting

to FCR during the assignment of cancer diagnosis to a patient in the electronic medical records could help improve the declining trend.

In conclusion, both FCR and HILMO have high completeness and validity in gastric cancer diagnoses. Clinicians are suggested to pay attention to reporting all new cases to FCR, and to consider not assigning cancer diagnoses during initial diagnostic workup to reduce potential false positives in the registries.

Funding

This study was supported by research grants from the Sigrid Jusélius Foundation (Sigrid Juséliuksen Säätiö), The Finnish Cancer Foundation (Syöpäsäätiö) and Päivikki and Sakari Sohlberg Foundation.

References

[1] Sung H, Ferlay J, Siegel R, Laversanne M, Soerjomataram I, Jemal A et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA: A Cancer Journal for Clinicians. 2021;71(3):209-249.

[2] Hu B, El Hajj N, Sittler S, Lammert N, Barnes R, Meloni-Ehrig A. Gastric cancer: Classification, histology, and application of molecular pathology. Journal of gastrointestinal oncology. 2012; 3(3), 251–261.

[3] Berlth F. Pathohistological classification systems in gastric cancer: Diagnostic relevance and prognostic value. World Journal of Gastroenterology. 2014;20(19):5679.

[4] Siewert J, Stein H. Classification of adenocarcinoma of the oesophagogastric junction. British Journal of Surgery. 1998;85(11):1457-1459.

[5] Joshi S, Badgwell B. Current treatment and recent progress in gastric cancer. CA: A Cancer Journal for Clinicians. 2021;71(3):264-279.

[6] Maret-Ouda J, Tao W, Wahlin K, Lagergren J. Nordic registry-based cohort studies: Possibilities and pitfalls when combining Nordic registry data. Scandinavian Journal of Public Health. 2017;45(17_suppl):14-19.

[7] Leinonen M, Miettinen J, Heikkinen S, Pitkäniemi J, Malila N. Quality measures of the population-based Finnish Cancer Registry indicate sound data quality for solid malignant tumours. European Journal of Cancer. 2017;77:31-39.

[8] Sund R. Quality of the Finnish Hospital Discharge Register: A systematic review. Scandinavian Journal of Public Health. 2012;40(6):505-515.

[9] Kauppila J, Ohtonen P, Karttunen T, Kokkola A, Laine S, Rantanen T et al. Finnish National Esophago-Gastric Cancer Cohort (FINEGO) for studying outcomes after oesophageal and gastric cancer surgery: a protocol for a retrospective, population-based, nationwide cohort study in Finland. BMJ Open. 2019;9(1):e024094.

[10] Kauppila J, Ohtonen P, Rantanen T, Tyrväinen T, Toikkanen V, Pääaho M et al. Cohort profile: gastric cancer in the population-based, Finnish National Esophago-Gastric Cancer Cohort (FINEGO) Study. BMJ Open. 2020;10(10):e039574.

[11] Lahti R, Penttilä A. The validity of death certificates: routine validation of death certification and its effects on mortality statistics. Forensic Science International. 2001;115(1-2):15-32.

[12] Official Statistics of Finland (OSF): Quality Description: Causes of death 2018 [internet]. Helsinki: Statistics Finland; 2018 [cited date: 2020-01-27]. Available from: http://www.stat.fi/til/ksyyt/2018/ksyyt_2018_2019-12-16_laa_001_en.html.

[13] Cutler SJ, Ederer F. Maximum utilization of the life table method in analysing survival. J Chronic Dis. 1958 Dec;8(6):699-712.

[14] Kauppila JH. Completeness of esophageal cancer diagnosis in the Finnish Cancer Registry and hospital discharge registry, a nationwide study in Finland. Acta Oncol. 2020 Nov;59(11):1329–1332.

[15] Lunkka P, Malila N, Ryynänen H, Heikkinen S, Sallinen V, Koskenvuo L. Accuracy of Finnish Cancer Registry colorectal cancer data: a comparison between registry data and clinical records. Scandinavian Journal of Gastroenterology. 2021;56(3):247-251.

[16] Kilander C, Mattsson F, Ljung R, Lagergren J, Sadr-Azodi O. Systematic underreporting of the population-based incidence of pancreatic and biliary tract cancers. Acta Oncologica. 2013;53(6):822-829.

Table 1. The characteristics and vital status with causes of death in gastric cancer patients reported to Finnish Cancer Registry (FCR) and Hospital Discharge Registry (HILMO)

Variable	FCR only n (%)	HILMO only n (%)	Both FCR and HILMO n (%)	Total n (%)
Total	1561 (7.3)	2800 (13.0)	17107 (79.7)	21468 (100)
Sex				
Female	801 (8.3)	1271 (13.1)	7636 (78.7)	9708 (100)
Male	760 (6.5)	1529 (13.0)	9471 (80.5)	11760 (100)
Age at diagnosis				
Up to 50 years	150 (8.3)	212 (11.7)	1452 (80.0)	1814 (100)
51-60 years	237 (7.8)	417 (13.8)	2367 (78.4)	3021 (100)
61-70 years	344 (6.7)	732 (14.2)	4087 (79.2)	5163 (100)
71-80 years	383 (5.7)	891 (13.3)	5431 (81.0)	6705 (100)
81-90 years	363 (8.4)	508 (11.8)	3429 (79.7)	4300 (100)
Over 90 years	84 (18.1)	40 (8.6)	341 (73.3)	465 (100)
Surgery				
No	1281 (10.2)	2200 (17.4)	9127 (72.4)	12608 (100)
Yes	280 (3.2)	600 (6.8)	7980 (90.1)	8860 (100)
Time period				
1990-1994	385 (7.3)	613 (11.7)	4242 (81.0)	5240 (100)
1995-1999	318 (7.1)	438 (9.8)	3729 (83.1)	4485 (100)
2000-2004	280 (6.7)	570 (13.6)	3345 (79.7)	4195 (100)
2005-2009	271 (6.9)	573 (14.7)	3059 (78.4)	3903 (100)
2010-2014	307 (8.4)	606 (16.6)	2732 (75.0)	3645 (100)
Vital status*				
Alive	361 (23.1)	440 (15.7)	1270 (7.4)	2071 (9.6)
Dead	1200 (76.9)	2360 (84.3)	15837 (92.6)	19397 (90.4)
Cause of death**				
Gastric cancer	566 (47.2)	259 (11.0)	13831 (87.3)	14656 (75.6)
Other	634 (52.8)	2101 (89.0)	2006 (12.7)	4741 (24.4)

FCR: Finnish Cancer Registry; HILMO: Hospital Discharge Registry.

*Calculated as the percentage of total patients in each group

**Calculated as the percentage of those who died

Table 2. The number of admissions for esophageal cancer and gastric cancer in Hospital Discharge Registry (HILMO), and esophageal cancer diagnoses in the Finnish Cancer Registry (FCR) in gastric cancer patients.

Variable	FCR only n (%)	HILMO only n (%)	Both FCR and HILMO n (%)	Total n (%)
Total	1561 (100)	2800 (100)	17107 (100)	21468 (100)
Number of gastric cancer admissions in HILMO				
0	1561 (100)	-	-	1561 (7.3)
1	-	1470 (52.5)	2465 (14.4)	3935 (18.3)
2 or more	-	1330 (47.5)	14642 (85.6)	15972 (74.4)
Number of esophageal cancer admissions in HILMO				
0	1311 (84.0)	2375 (84.8)	16343 (95.5)	20029 (93.3)
1	27 (1.7)	47 (1.7)	266 (1.6)	340 (1.6)
2 or more	223 (14.3)	378 (13.5)	498 (2.9)	1099 (5.1)
Esophageal cancer diagnosis in gastric cancer patients in FCR				
No	1555 (99.6)	2363 (84.4)	17091 (99.9)	21009 (97.9)
Yes	6 (0.4)	437 (15.6)	16 (0.1)	459 (2.1)

FCR: Finnish Cancer Registry; HILMO: Hospital Discharge Registry.

Figure caption:

Figure 1. Kaplan-Meier curve depicting 5-year all-cause mortality in gastric cancer patients stratified by registry status. The red line represents those in FCR only, the blue line represents those patients registered in HILMO only, and the green line represents those in both FCR and HILMO.

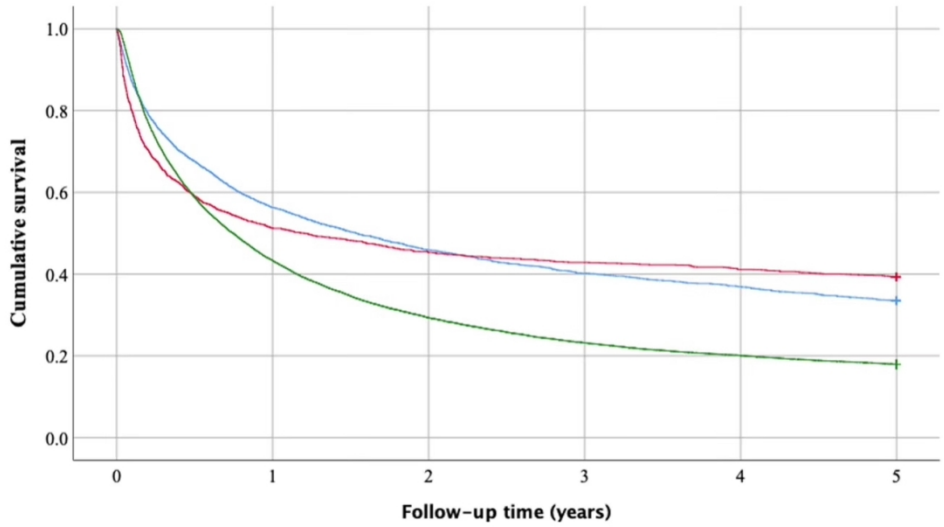

Figure 1. Kaplan-Meier curve depicting 5-year all-cause mortality in gastric cancer patients stratified by registry status. The red line represents those in FCR only, the blue line represents those patients registered in HILMO only, and the green line represents those in both FCR and HILMO.

117x64mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*6*
Bias	9	Describe any efforts to address potential sources of bias	n/a
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	n/a
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	17
		(c) Summarise follow-up time (eg, average and total amount)	17
Outcome data	15*	Report numbers of outcome events or summary measures over time	17
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Gastric cancer completeness in Finnish Cancer Registry and Finnish Patient Registry, a population-based nationwide retrospective cohort study

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Gastric cancer completeness in Finnish Cancer Registry and Finnish Patient Registry, a population-based nationwide retrospective cohort study

Authors: Urgena Maharjan[1], Joonas H. Kauppila[1,2]

Affiliations: [1]Surgery Research Unit, Medical Research Center Oulu, Oulu University Hospital and University of Oulu, Oulu, Finland; [2]Upper Gastrointestinal Surgery, Department of Molecular Medicine and Surgery, Karolinska Institutet and Karolinska University Hospital, Stockholm, Sweden.

Corresponding author: Urgena Maharjan, Surgery Research Unit, MRC Oulu, Oulu University Hospital and University of Oulu, P.O. Box 8000, 90014 Oulu
Email: urgena.maharjan@oulu.fi

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Keywords: surgery, oncology, gastroenterology, gastrointestinal tumours, epidemiology, public health

Abstract

Background: Gastric cancer is the fourth leading cause of cancer related deaths worldwide. The only curative treatment options of gastric cancer are perioperative chemotherapy and surgical resection. Many nationwide registries have high validity and provide vast range of opportunities for registry-based research. Cancer diagnoses in the Finnish Cancer Registry (FCR) are reported by pathology laboratories and clinician forms, while discharge diagnosis codes are reported to the Finnish Patient Registry (HILMO) automatically. Finland is known for complete registries but the completeness of gastric cancer in FCR and HILMO remains unclear.

Objectives: The aim of this study is to assess the registry coverage for gastric cancer in FCR and HILMO and to explore potential reasons for possible differences between these registries.

Design: Population-based nationwide retrospective cohort study.

Participants: All patients diagnosed with gastric cancer in Finland during 1990 to 2014, with follow- up until December 31, 2019.

Results: Out of 21,468 total gastric cancers reported to either registry, 17,107 (79.7%) had a gastric cancer diagnosis in both registries. A substantial decrease from 88.3% to 83.4% was observed in the proportion of cases reported to FCR over time. The completeness of FCR was estimated at 87%. For HILMO, the completeness was 92.7%. Death due to gastric cancer was most common in those with gastric cancer in both registries (80.8%), and less common in those reported to only FCR (36.3%), followed by those reported to only HILMO (9.3%).

Conclusions: The study indicates that gastric cancer is well captured by both FCR and HILMO but there is an alarming decrease in the proportion of cases captured by the Finnish Cancer Registry over time. Some gastric cancer diagnoses in HILMO might, however, be misclassified due to cancer diagnoses being assigned based on clinical suspicion.

Article Summary

Strengths and limitations of this study:

- The main strength of this study is the population- based nationwide design.
- The size of the cohort was large with a complete follow-up of all patients diagnosed with gastric cancer in Finland.
- The population-based design of this study and complete follow-up of participants counteracts any selection-bias.
- The limitation of the study is the unavailability of medical records for the assessment of validity of diagnoses.

Funding statement:

This work is supported by research grants from the Sigrid Jusélius Foundation (Sigrid Juséliuksen Säätiö), The Finnish Cancer Foundation (Syöpäsäätiö), and Päivikki and Sakari Sohlberg Foundation. The funding sources have no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the study protocol for publication.

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Author contributions:

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Data sharing statement:

All data presented in this article are available from THL/Findata, Finland. Data access to collaborators can be granted given that relevant government and health officials approve the collaborative study.

Introduction

Gastric cancer is declining in incidence but remains the fourth leading cause of cancer-related death around the world [1]. Gastric cancers are anatomically classified into gastric cardia cancer, including Siewert type II cancer and gastric non-cardia cancer, including true gastric adenocarcinomas and Siewert type III cancer [2-4]. Currently the only curative treatment of gastric adenocarcinoma, the most prevalent gastric cancer, is surgical resection with or without perioperative chemotherapy [5].

The nationwide Nordic registries with high validity provide excellent opportunities for registry-based medical research and cohort studies with long and complete follow-up [6]. Finland is known for complete and accurate registries e.g., the Finnish Cancer Registry (FCR) reporting cancer statistics, and the Finnish Patient Registry (HILMO) collecting hospital discharge diagnoses and surgical codes for statistical and governmental purposes [7, 8].

A previous study in Finland showed that FCR data had good accuracy regarding colorectal cancer [9]. Completeness of both FCR and HILMO was found to be above 90% for esophageal cancer [10]. However, completeness of gastric cancer diagnosis in FCR and HILMO still remains unclear. Therefore, the quality of these registries must be evaluated for their proper utilization in future research.

The aim of this study is to assess the registry coverage for gastric cancer in FCR and HILMO and to explore potential reasons for possible differences between registries.

Methods

Study design

A population-based nationwide retrospective cohort study of all gastric cancer patients in Finland during 1990-2014 was conducted. This study was approved by the Northern Ostrobothnia ethical committee (EETMK 115/2016). Informed consent was not required [11, 12].

Data sources

The data on gastric cancer was retrieved from the Finnish Cancer registry (FCR) and the Finnish Patient Registry (HILMO). All the patients who had gastric cancer in either FCR or HILMO were identified using respective ICD-9 (151) and ICD-10 (C16) codes. Mortality was evaluated from the death registry held by Statistics Finland. Unique immutable personal identification number assigned to all residents in Finland were used to combine registry data.

The Finnish cancer registry (FCR) and patient registry (HILMO) are comprehensive registries as all healthcare units in Finland are obligated to enter patient and treatment data into these registries. FCR includes all incident cancers from the population of Finland since the year 1953. These data are usually input by clinicians by using paper-, and more recently electronical forms and semi-automatic reporting of cancer from pathology and cytology laboratories. FCR collects information on cancer type, date of diagnosis, location of cancer from laboratory notifications and treatment information from both clinical and laboratory notifications [7]. However, as these notifications are based on histological or cytological confirmation, or a form filled by a

clinician, some cancers many be missed. HILMO on the other hand, is completely independent from FCR and includes information on discharge dates, diagnosis and operation codes assigned by clinicians to every patient during each admission. Codes for open and minimally invasive esophagectomy and gastrectomy (codes 620x, 630x, 631x, 632x, and 636x in the Finnish Surgical codes prior to 1996, and codes JCCxx, JDCxx and JDDxx in the Nordic Classification of Surgical Procedures (NOMESCO) from 1996 and onwards), and endoscopic mucosal resection (EMR) and endoscopic submucosal dissection (ESD) (NOMESCO codes JCA45, JCA52, JDA45, JDA52, and JDH52) were used for identification of surgical treatment in patients with a diagnosis of gastric cancer. As some gastric cardia cancers are assigned with esophageal procedure codes, both esophageal and gastric surgery codes were included when used with a gastric patient diagnosis. The hospital administration reports these codes electronically and automatically into the patient registry on discharge. Reimbursements from the municipalities are based on these same diagnosis and operation codes. Furthermore, these discharge codes are used by governmental bodies to calculate the healthcare district and municipality-specific rates of healthcare costs and morbidity indices, that serve as the basis of healthcare funding to the municipalities and hospital districts from the government. More than 99% of hospital discharges are reported to HILMO [8].

Statistics Finland death registry provides information on patient death, date of death and its primary and secondary causes. Death information is input by clinicians into the death certificates which include description of patients' disease and cause of death based on evaluation or autopsies [13]. The correctness of all death certificates is checked by forensic physicians before they are recorded in Statistics Finland causes of death. The completeness of the registry is 100% for date of death and >99% for cause of death [14].

Statistical analysis

The data was retrieved from FCR and HILMO from the period of 1987-2016. Cancer diagnoses during the first three years were excluded to reliably identify the earliest cancer incidence and the last two years were omitted due to potential time lag in reporting, resulting in time period of 25 years from 1990 to 2014. Patients diagnosed only in autopsies were excluded. Death data was available until 2019, resulting in a minimum follow-up of 5 years for all patients.

For analysis of completeness, the three sub-populations were derived from the total cohort: 1) those present in FCR only 2) those present in HILMO only and 3) those present in both FCR and HILMO. The proportions of patients in these three groups were calculated in total and stratified in terms of sex, age, calendar period, surgery, causes of death and gastric cancer records in HILMO and FCR. The death registry was used to identify those who died of gastric cancer. Survival analysis was conducted to examine the mortality patterns in the different groups with life table method [15] and plotted using Kaplan-Meier curves to indirectly evaluate whether there were major differences in the accuracy of gastric cancer recording, as these cancers are known to have high mortality.

Permissions and registration

The study has been approved by ethical committee in Northern Osthrobothnia (EETMK 115/2016), The National Institute for Health and Welfare (THL/169/5.05.00), Statistics Finland (TK-53-1478-17) and the Office of the Data Protection Ombudsman (Dnro 506/402/17), Finland. Individual informed consent was not sought from the patients, as obtaining the informed consent was waived by the Finnish law. The study was conducted in accordance with the Declaration of Helsinki.

Patient and public involvement

Patients or public were not involved in the development of the research question and study design or conducting the present study.

Results

Patients

Of the total 22,121 gastric cancers diagnosed in 1990-2014, 19,907 had a gastric cancer diagnosis in HILMO, and 19,321 in FCR. Considering all patients with gastric cancer in the FCR, the Death Certificate Only (DCO) rate was 1.4% (n=268). Of those with gastric cancer diagnosis only in FCR, 653 were diagnosed during autopsy were excluded from further analyses.

After exclusion, there was a total of 21,468 gastric cancers reported in either registry of FCR and HILMO during the 25 years. Among these cases 17,107 (79.7%) were reported to both FCR and HILMO, 1,561 (7.3%) were reported only to FCR and 2,800 (13.0%) were reported only to HILMO (Table 1). Based on these numbers, FCR captured 87.0% of gastric cancers, and HILMO captured 92.7% of gastric cancers.

Of the total cases, 11,760 (54.8%) were male and 9,708 (45.2%) were female. The median age for diagnosis was 70 years. The highest number of patients were observed during the period of 1990-1994 which was 5,240 (24.4%). Surgical treatment was received by 8,860 (41.3%) of total patients, including 80 patients with ESD or EMR. No major differences were observed in the reporting to the registries in terms of sex and age group. Surgically treated patients were more often reported to both registries than those without surgery. A considerable decrease from 88.3% in 1990-1994 to 83.4% in 2010-2014 was observed in the proportion of cases reported to FCR over time (Table 1).

Of all patients (19,397) who died, 14,656 (75.6%) died of gastric cancer and 4,741 (24.4%) died of other causes. A majority of deaths were observed in those reported to both FCR and HILMO (Table 1).

Patients reported in FCR only

Of 1,561 patients who were reported to FCR only, 566 (36.3%) died of gastric cancer, 634 (40.6%) died of other causes and the rest 361 (23.1%) were still alive (Table 1). No esophageal cancer diagnosis was recorded in HILMO for 1,311 (84.0%), suggesting low misclassification. Admissions for esophageal cancers were recorded in 250 (16.0%) patients, but only 6 (0.4%) had esophageal cancer recorded in FCR (Table 2).

Patients reported in HILMO only

Of 2,800 patients who were reported to HILMO only, 259 (9.3%) died of gastric cancer, 2,101 (75.0%) died of other causes, leaving 440 (15.7%) alive (Table 1). Admissions for esophageal cancers were recorded in 425 (15.2%) patients, and esophageal cancer was recorded in FCR for 437 (15.6%) of the patients (Table 2).

Patients reported in both

Of 17,107 patients reported to both FCR and HILMO (Table 1), 13,831 (80.8%) died of gastric cancer, 2,006 (11.7%) died of other causes and the rest 1,270 (7.4%) were still alive (Table 1). A majority (85.6%) had two or more gastric cancer admissions and no admission for esophageal cancer (95.5%, Table 2).

Mortality

As gastric cancer is known to have high mortality rate, survival analysis was conducted to further evaluate the accuracy of gastric cancer diagnoses in each of the groups. The 5- year mortality in all groups were high. Those who were reported to only HILMO, or only FCR had lower mortality than those who were reported to both FCR and HILMO (Figure 1).

Discussion

The study shows that gastric cancer is well captured by both FCR and HILMO registries but there is an alarming decrease in the proportion of cases captured by FCR over time.

Some of the strengths of the study include the population- based nationwide design and a large size of cohort with a complete follow-up of all patients diagnosed with gastric cancer in Finland preventing any selection-bias. A weakness of the study is the unavailability of medical records for the assessment of validity of diagnoses.

The proportions of gastric cancer reported to FCR, HILMO and both were relatively similar between sex and age groups. Surgical patients were more often reported to both FCR and HILMO, suggesting that palliative and/or patients not undergoing surgical resection might be more often missed by either of these registries. A significant decline in reporting to FCR was observed over time. As reporting to HILMO is based on administration, but FCR relies on reporting by physicians, physician workload and lack of clarity in responsibilities of reporting might influence this phenomenon. Even though reporting to FCR is mandated by legislation, it might be that physicians do not see reporting new cancer cases to FCR as important part of cancer treatment, or that reporting is missed due to lack of impact on the treatment of the patient. Even though the laboratories automatically report these cases to the FCR, some diagnoses in which histological confirmation is not sought, might still be missed. Lastly, some malignant tumors of lower malignancy grade, such as gastric neuroendocrine tumors might be more likely to be missed by cancer registry, as suggested by better survival in those patients only reported to FCR compared to being reported to both registries.

Gastric cancer is associated with high mortality. FCR might have a higher specificity of cancer diagnoses in comparison to HILMO, reflected by slightly higher proportion of gastric cancer deaths reported to only FCR compared to those reported to only HILMO. Furthermore, half of those patients not reported to only HILMO had only one gastric cancer admission in HILMO, while the other half had two or more admissions, potentially reflecting cases where cancer diagnosis was assigned to a patient during evaluation for suspected cancer, but this diagnosis was then not confirmed later. In survival analysis, mortality in all groups was high, supporting the view that the specificity of gastric cancer diagnoses was relatively high in also those missed by either FCR or HILMO. The survival curves showed that the mortality was lower in those reported to only HILMO and those reported to only FCR, compared to those reported to both, suggesting that some misclassification or lower malignancy tumors might be included in patients not reported to both registries. Previously reported possible misclassification between distal esophageal and gastric (cardia) cancer [10] was deemed low based on the low number of esophageal cancer deaths and esophageal cancer admissions in this cohort of gastric cancer patients.

The estimated completeness of gastric cancer was 87.0% for FCR and 92.7% for HILMO. Previously, both FCR and HILMO have shown to have above 90% completeness for esophageal cancer [10]. A good accuracy of FCR was also indicated by a similar study for colorectal cancer [9]. A Swedish study, on the other hand, indicated a substantial underreporting of pancreatic and biliary cancers in the Swedish Cancer Registry [16]. Based on these figures, both FCR and HILMO can be reliably used for registry research in gastric cancer. To turn the decreasing trend of reporting to FCR, clinicians are recommended to report all gastric cancer patients to FCR at all stages of diagnosis and treatment. Automatic reporting

to FCR during the assignment of cancer diagnosis to a patient in the electronic medical records could help improve the declining trend.

In conclusion, both FCR and HILMO have high completeness and validity in gastric cancer diagnoses. Clinicians are suggested to pay attention to reporting all new cases to FCR, and to consider not assigning cancer diagnoses during initial diagnostic workup to reduce potential false positives in the registries.

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References

[1] Sung H, Ferlay J, Siegel R, Laversanne M, Soerjomataram I, Jemal A et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA: A Cancer Journal for Clinicians. 2021;71(3):209-249.

[2] Hu B, El Hajj N, Sittler S, Lammert N, Barnes R, Meloni-Ehrig A. Gastric cancer: Classification, histology, and application of molecular pathology. Journal of gastrointestinal oncology. 2012; 3(3), 251–261.

[3] Berlth F. Pathohistological classification systems in gastric cancer: Diagnostic relevance and prognostic value. World Journal of Gastroenterology. 2014;20(19):5679.

[4] Siewert J, Stein H. Classification of adenocarcinoma of the oesophagogastric junction. British Journal of Surgery. 1998;85(11):1457-1459.

[5] Joshi S, Badgwell B. Current treatment and recent progress in gastric cancer. CA: A Cancer Journal for Clinicians. 2021;71(3):264-279.

[6] Maret-Ouda J, Tao W, Wahlin K, Lagergren J. Nordic registry-based cohort studies: Possibilities and pitfalls when combining Nordic registry data. Scandinavian Journal of Public Health. 2017;45(17_suppl):14-19.

[7] Leinonen M, Miettinen J, Heikkinen S, Pitkäniemi J, Malila N. Quality measures of the population-based Finnish Cancer Registry indicate sound data quality for solid malignant tumours. European Journal of Cancer. 2017;77:31-39.

[8] Sund R. Quality of the Finnish Hospital Discharge Register: A systematic review. Scandinavian Journal of Public Health. 2012;40(6):505-515.

[9] Lunkka P, Malila N, Ryynänen H, Heikkinen S, Sallinen V, Koskenvuo L. Accuracy of Finnish Cancer Registry colorectal cancer data: a comparison between registry data and clinical records. Scandinavian Journal of Gastroenterology. 2021;56(3):247-251.

[10] Kauppila JH. Completeness of esophageal cancer diagnosis in the Finnish Cancer Registry and hospital discharge registry, a nationwide study in Finland. Acta Oncol. 2020 Nov;59(11):1329–1332.

[11] Kauppila J, Ohtonen P, Karttunen T, Kokkola A, Laine S, Rantanen T et al. Finnish National Esophago-Gastric Cancer Cohort (FINEGO) for studying outcomes after oesophageal and gastric cancer surgery: a protocol for a retrospective, population-based, nationwide cohort study in Finland. BMJ Open. 2019;9(1):e024094.

[12] Kauppila J, Ohtonen P, Rantanen T, Tyrväinen T, Toikkanen V, Pääaho M et al. Cohort profile: gastric cancer in the population-based, Finnish National Esophago-Gastric Cancer Cohort (FINEGO) Study. BMJ Open. 2020;10(10):e039574.

[13] Lahti R, Penttilä A. The validity of death certificates: routine validation of death certification and its effects on mortality statistics. Forensic Science International. 2001;115(1-2):15-32.

[14] Official Statistics of Finland (OSF): Quality Description: Causes of death 2018 [internet]. Helsinki: Statistics Finland; 2018 [cited date: 2020-01-27]. Available from: http://www.stat.fi/til/ksyyt/2018/ksyyt_2018_2019-12-16_laa_001_en.html.

[15] Cutler SJ, Ederer F. Maximum utilization of the life table method in analysing survival. J Chronic Dis. 1958 Dec;8(6):699-712.

[16] Kilander C, Mattsson F, Ljung R, Lagergren J, Sadr-Azodi O. Systematic underreporting of the population-based incidence of pancreatic and biliary tract cancers. Acta Oncologica. 2013;53(6):822-829.

Table 1. The characteristics and vital status with causes of death in gastric cancer patients reported to Finnish Cancer Registry (FCR) and Hospital Discharge Registry (HILMO)

Variable	FCR only n (%)	HILMO only n (%)	Both FCR and HILMO n (%)	Total n (%)
Total	1561 (7.3)	2800 (13.0)	17107 (79.7)	21468 (100)
Sex				
Female	801 (8.3)	1271 (13.1)	7636 (78.7)	9708 (100)
Male	760 (6.5)	1529 (13.0)	9471 (80.5)	11760 (100)
Age at diagnosis				
Up to 50 years	150 (8.3)	212 (11.7)	1452 (80.0)	1814 (100)
51-60 years	237 (7.8)	417 (13.8)	2367 (78.4)	3021 (100)
61-70 years	344 (6.7)	732 (14.2)	4087 (79.2)	5163 (100)
71-80 years	383 (5.7)	891 (13.3)	5431 (81.0)	6705 (100)
81-90 years	363 (8.4)	508 (11.8)	3429 (79.7)	4300 (100)
Over 90 years	84 (18.1)	40 (8.6)	341 (73.3)	465 (100)
Surgery				
No	1281 (10.2)	2200 (17.4)	9127 (72.4)	12608 (100)
Yes	280 (3.2)	600 (6.8)	7980 (90.1)	8860 (100)
Time period				
1990-1994	385 (7.3)	613 (11.7)	4242 (81.0)	5240 (100)
1995-1999	318 (7.1)	438 (9.8)	3729 (83.1)	4485 (100)
2000-2004	280 (6.7)	570 (13.6)	3345 (79.7)	4195 (100)
2005-2009	271 (6.9)	573 (14.7)	3059 (78.4)	3903 (100)
2010-2014	307 (8.4)	606 (16.6)	2732 (75.0)	3645 (100)
Vital status*				
Alive	361 (23.1)	440 (15.7)	1270 (7.4)	2071 (9.6)
Dead	1200 (76.9)	2360 (84.3)	15837 (92.6)	19397 (90.4)
Cause of death**				
Gastric cancer	566 (47.2)	259 (11.0)	13831 (87.3)	14656 (75.6)
Other	634 (52.8)	2101 (89.0)	2006 (12.7)	4741 (24.4)

FCR: Finnish Cancer Registry; HILMO: Hospital Discharge Registry.

*Calculated as the percentage of total patients in each group

**Calculated as the percentage of those who died

Table 2. The number of admissions for esophageal cancer and gastric cancer in Hospital Discharge Registry (HILMO), and esophageal cancer diagnoses in the Finnish Cancer Registry (FCR) in gastric cancer patients.

Variable	FCR only n (%)	HILMO only n (%)	Both FCR and HILMO n (%)	Total n (%)
Total	1561 (100)	2800 (100)	17107 (100)	21468 (100)
Number of gastric cancer admissions in HILMO				
0	1561 (100)	-	-	1561 (7.3)
1	-	1470 (52.5)	2465 (14.4)	3935 (18.3)
2 or more	-	1330 (47.5)	14642 (85.6)	15972 (74.4)
Number of esophageal cancer admissions in HILMO				
0	1311 (84.0)	2375 (84.8)	16343 (95.5)	20029 (93.3)
1	27 (1.7)	47 (1.7)	266 (1.6)	340 (1.6)
2 or more	223 (14.3)	378 (13.5)	498 (2.9)	1099 (5.1)
Esophageal cancer diagnosis in gastric cancer patients in FCR				
No	1555 (99.6)	2363 (84.4)	17091 (99.9)	21009 (97.9)
Yes	6 (0.4)	437 (15.6)	16 (0.1)	459 (2.1)

FCR: Finnish Cancer Registry; HILMO: Hospital Discharge Registry.

Figure caption:

Figure 1. Kaplan-Meier curve depicting 5-year all-cause mortality in gastric cancer patients stratified by registry status. The red line represents those in FCR only, the blue line represents those patients registered in HILMO only, and the green line represents those in both FCR and HILMO.

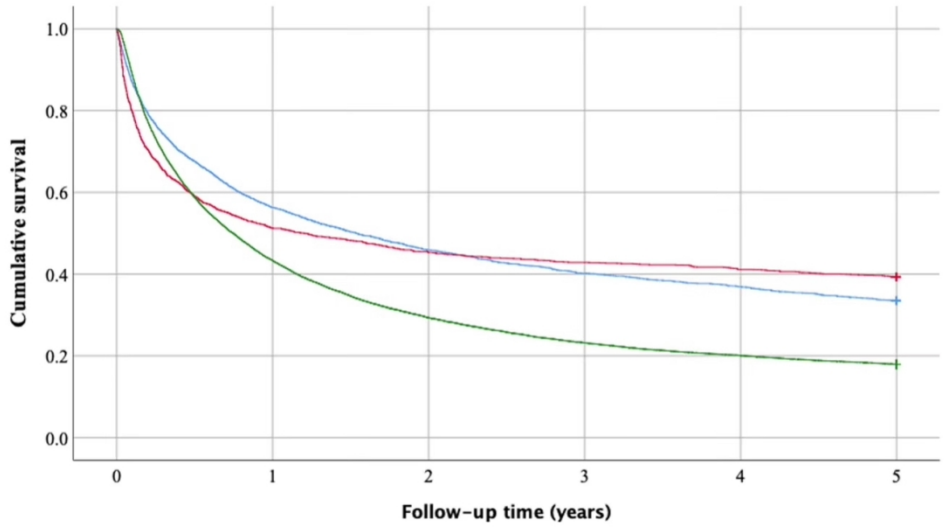

Figure 1. Kaplan-Meier curve depicting 5-year all-cause mortality in gastric cancer patients stratified by registry status. The red line represents those in FCR only, the blue line represents those patients registered in HILMO only, and the green line represents those in both FCR and HILMO.

117x64mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7*
Bias	9	Describe any efforts to address potential sources of bias	n/a
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	n/a
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	17
		(c) Summarise follow-up time (eg, average and total amount)	17
Outcome data	15*	Report numbers of outcome events or summary measures over time	17
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.