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Using health administrative data to identify patients with pulmonary hypertension: A single center, proof of concept validation study in Ontario, Canada

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Abstract

Real-world identification of pulmonary hypertension (PH) is largely based on the use of administrative databases identified by ICD codes. This approach has not been validated. The aim of this study was to validate a diagnosis of PH and its comorbidities using ICD 9/10 codes. Health records from Kingston Health Sciences Centre (2010 to 2012) were abstracted to identify a diagnosis of PH. Cohort 1 patients ($n = 300$) were selected because they had attended a cardiology or respirology clinic without knowledge of PH status. Cohort 2 patients ($n = 200$) were patients with a diagnosis of PH, identified using International Classification of Diseases (ICD) codes at the time of hospitalizations (CIHI-DAD) or emergency department (ED) visits (CIHI-NACRS). These cohorts were combined and reviewed to validate the diagnosis of PH. These data were securely transferred to the Institute of Clinical Evaluative Sciences (ICES). The diagnosis of PH from chart abstraction was used as the gold standard. The classification of PH into WHO groups, based on chart abstraction, was also compared to classification based on ICD code-defined comorbidities. Cohort 1 and Cohort 2 were merged to yield 449 unique patients in the combined cohort. In the combined cohort, 248 of 449 (55.2%) had a diagnosis of PH by ICD code criteria. The mean age of this PH group was 70 years, and the majority were females (65.5%). One hospitalization or ED visit resulting in a diagnostic code for PH had a sensitivity of 73% and a specificity of 99% for a confirmed PH diagnosis on chart abstraction. When WHO classification by chart abstraction and ICD codes for comorbidities were compared, there was 87% agreement. Identification of PH and its comorbidities using ICD codes is a valid approach, and this single-center study supports its application to identify PH.

KEYWORDS
health administrative data, population studies, pulmonary hypertension, validation

INTRODUCTION

Pulmonary hypertension (PH) is a disease with significant morbidity and mortality. At the time of this study, PH was defined as an elevated mean arterial pressure (mPAP) of ≥ 25 mmHg at rest,[1] although recently diagnostic criteria have been liberalized to include patients with mPAP > 20 mmHg.[1] In practice, the diagnosis of PH is made by Doppler echocardiography or right heart catheterization (RHC). The World Health Organization (WHO) recognizes five PH groups.[2] PH syndromes, when one includes all five WHO groups, are not rare. A 20-year, retrospective study of ~50,000 PH patients in the Institute of Clinical Evaluative Sciences (ICES) registry identified a prevalence of PH in Ontario (Canada) of 127 cases/100,000 population with an incidence of 29 cases/100,000 population.[3] PH, regardless of WHO Group, is lethal, with a 1-year standardized mortality ratio of 7.2.[3]

Epidemiological information on PH at the population level, meaning outside of clinical trials and registries, is sparse. Previous epidemiological studies have primarily focused on adult PH patients with Group 1 disease. One such study was conducted in over 680 outpatients at a referral center, looking at Pulmonary arterial hypertension (PAH) and only captures ICD 9 diagnoses.[4] Another study examined a cohort from US veterans (VA) and a PH referral center and attempted to describe PH comorbidities. A large proportion of patients were from the VA cohort (12,000 vs. 500 from a PH referral center) and hence was predominantly male, limiting generalizability as PH is significantly more prevalent in females.[5] Both these studies use complex algorithms incorporating variables such as right heart catheterization, that is often sparse and not pragmatic in population level studies.

Only two studies included information on groups other than Group 1. A population-based Australian study of over 10,000 patients found that Group 2 PH was the most common and lethal form of PH.[6] A Spanish study of Group 1 (866 PAH) and Group 4 (162 chronic thromboembolic PH) patients noted 1, 3, and 5-year survival rates of 87%, 75%, and 65%, respectively, with no intergroup differences.[7] The few epidemiological studies of PH performed in Canada, with the exception of our prior study,[3] have not been population-based and have focused on small, but very well phenotyped, cohorts of Group 1 patients.[8,9]

The challenge of the epidemiology at expert centers is smaller sample size, referral bias, and perhaps a tendency to focus on patients on pharmacologic therapy; however, the advantage of single-center studies is high diagnostic accuracy, based on the in-person case assessment and expert opinion buttressed by comprehensive testing including RHC. Cohorts from expert centers also have high rates of follow-up and can accurately establish WHO Group classification and measure outcomes.

In contrast, the advantages of population studies include larger sample sizes and fewer exclusion criteria. A population cohort can demonstrate the true impact of the disease without socioeconomic or referral biases. However, the challenge of population-based studies is to ensure accurate identification of patients as having PH using the limited, real-world data. This is a challenge both to the integrity of the diagnosis of PH and to the WHO classification of PH. In Ontario, healthcare utilization can be tracked using health administrative codes of Emergency department (ED) visits and hospitalizations available through the Institute of Clinical Evaluative Sciences (ICES). Numerous chronic diseases have been evaluated at the population level using health administration data, including asthma, chronic obstructive pulmonary disease (COPD), diabetes, and hypertension.[10–12] Validation of real-world cohorts of people with these diseases has enabled ongoing research on a multitude of health outcomes and health seeking behaviors. Examples of data derived from the use of health administrative data in these studies include determination of: mortality[13] and morbidity[14] of asthma, outcomes of COPD,[15] mortality trends in patients with diabetes,[16] prevalence and incidence[17] in addition to mortality among patients with hypertension.[18] Validation has not previously been performed for population-based PH studies.

We conducted a chart-abstraction validation study at a tertiary care center in Ontario, Kingston Health Sciences Center (KHSC), to examine the utility of using administrative codes to identify PH patients and perform a WHO Group classification at a population level. To stratify PH patients into WHO PH groups using health administrative data and further refine data analysis, we used ICD 9/10 codes for the comorbidities that are used by clinicians to categorize PH patients, such as the presence or absence of left heart disease (LHD), lung disease or thromboembolic disease.

METHODS

This study was conducted at the KHSC, in Ontario, Canada, with the goal of validating health administrative codes used for PH diagnosis in the Canadian Institute for Health Information Discharge Abstract Database, (CIHI-DAD) database, and the National Ambulatory Care Reporting System (CIHI-NACRS) database for outpatient ED visits. This study involved both case validation using chart abstraction by a physician and transfer/linkage of this information to the ICES registry to

evaluate the use of ICD codes in identifying PH in health administrative data.

Chart abstraction

Health records from KHSC were abstracted to validate a PH diagnosis. We studied two patient cohorts, one with an unknown PH status and another with a presumptive diagnosis of PH by ICD code based on hospital records. See (Figure 1) for a flow diagram of patients.
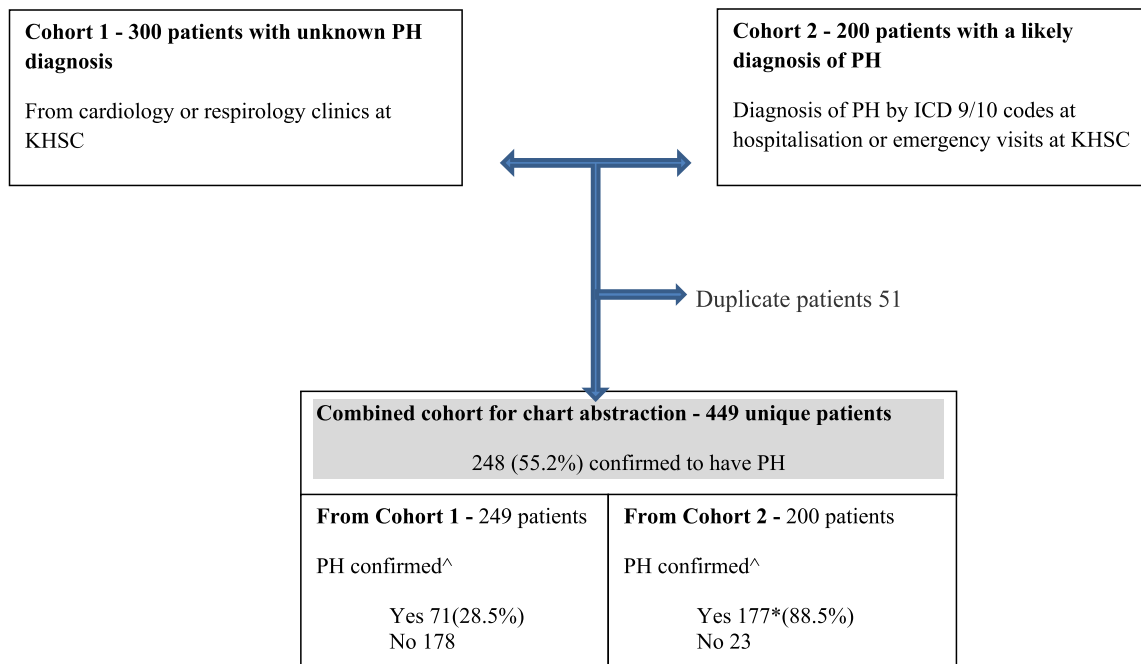
Cohort 1—Charts for 300 unique adult patients (≥18 years of age) who attended either a cardiology or respirology clinic from January 1st, 2010, to December 31st, 2012, at KHSC, for evaluation of a cardiac or pulmonary comorbidity. The PH status of the people in this cohort was unknown (i.e., they were not selected because they had an established PH diagnosis), and they were screened for a diagnosis of PH as part of this study. These patients were selected sequentially after generating a list of patients who visited the respective clinics. One hundred unique patients were selected from each calendar year (50 each selected from cardiology and respirology clinics).

Cohort 2—This cohort included 200 patients with a diagnosis of primary or secondary PH (defined as having one or more of the following ICD 9 Codes 416.0, 416.1, 416.8, 416.9 or ICD 10 Codes I27.0, I27.1, I27.2, I27.8, I27.9), captured through an ED visit or hospitalization at KHSC between January 1st, 2010, to December 31st, 2012.

Both Cohorts 1 and 2 were combined and duplicate patients removed, creating a combined cohort of 449 unique patients. Medical charts for this combined cohort were reviewed for a diagnosis of PH by two physician authors independently (Dr. DTW is a board-certified physician in Internal Medicine and Dr. AH, Senior resident in Internal Medicine). Chart abstraction was performed on electronic charts. Both abstractors were trained and supervised by an author Dr. SA who is an expert in PH. He supervised the abstraction of the first 10 charts of each abstractor and randomly validated 10% of the other charts. Also, disparities of the abstractors were resolved by consensus and input from the supervising author. The agreement between the abstractors had a kappa value of 0.82.

The diagnosis of PH was manually verified by screening all relevant investigations and procedures for the presence of PH on echocardiography or RHC evaluation. We considered PH to be confirmed if we detected right ventricular systolic pressure >40 mmHg by echo or

Cohort 1 - 300 patients with unknown PH diagnosis	Cohort 2 - 200 patients with a likely diagnosis of PH
From cardiology or respirology clinics at KHSC	Diagnosis of PH by ICD 9/10 codes at hospitalisation or emergency visits at KHSC

Duplicate patients 51

Combined cohort for chart abstraction - 449 unique patients

248 (55.2%) confirmed to have PH

From Cohort 1 - 249 patients	From Cohort 2 - 200 patients
PH confirmed^	PH confirmed^
Yes 71(28.5%) No 178	Yes 177*(88.5%) No 23

KHSC Kingston Health Sciences Hospital
PH – Pulmonary Hypertension
ICD- International Classification of Disease
*These 177patients from cohort 2 were used to identify WHO PH comorbidities
^All patients with PH had an echo-based diagnosis. In cohort 1, 15/71(21.1%) underwent Right Heart Catheterization(RHC); 88.5% in Cohort 2 (177/200 had RHC.

FIGURE 1 Flow diagram of patients used for chart abstraction and validation

mPAP > 25 mmHg by RHC, using the standards that were then current.[19] All echocardiograms were read by level III echocardiographers, who are qualified to interpret this type of study and are certified as outlined by the Canadian Cardiovascular Society (CCS) or equivalent.[20] This chart abstraction was used as the gold standard for the diagnosis of PH. Discrepancies were resolved by consensus. The diagnosis of PH was confirmed by reviewing charts of the combined cohort, examining data from the period extending from 5 years before to 2 years after the date of the encounter (date of clinic visit for Cohort 1 and the date of hospitalization or ED visit for Cohort 2). The 2-year follow-up period was included as some patients may have only been diagnosed with PH after initial workup following their captured healthcare visits. We chose a relatively lengthy time window to capture PH, given the natural history and the potential long delays from symptom onset to definitive diagnosis.[21]

Data transfer and linkage to ICES

Patient information from the combined cohort, including Ontario health card number, date of birth, date of health encounter, and verified diagnosis of PH (yes or no), was securely transferred and linked to the ICES registries, which comprise databases of universal coverage health service records for Ontario residents who have Ontario Health Insurance Plan (OHIP) coverage. OHIP covers most physician and hospital services. Hospitalization data were obtained from the CIHI-DAD database, and outpatient ED visits were retrieved from the CIHI-NACRS database. Demographic information was obtained from the Registered Persons Database (RPDB). Patients for whom there was missing information on gender or age were excluded from the cohort. Databases were linked using unique individual identifiers by deterministic linkage and were subsequently analyzed at ICES. All supporting data are available within this article and its online supplementary files. The data set from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet pre-specified criteria for confidential access (available at www.ices.on.ca/DAS). The full data set creation plan is available from the authors upon request.

Validation of the diagnosis of PH

The KHSC cohort data were linked to the patients' provincial records and compared with health administrative algorithms designed to identify PH. Multiple algorithms of PH diagnosis using the administrative data were compared (1 hospitalization with PH, 1 ED visit with PH, 1 hospitalization OR 1 ED visit with PH, 1 hospitalization and 1 ED visit with PH, 2 of hospitalizations or ED visits with PH). The same time window used for chart abstraction (5 years before to 2 years after index date) was used to identify PH codes. Any primary or secondary diagnoses of PH were captured using ICD 9/10 codes. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV), area under the curve (AUC), and likelihood ratios (LR) for each of the algorithms were then calculated against the gold standard diagnosis of PH, which in this study was based on expert chart abstraction.

Exploring PH comorbidities and WHO PH groups

Information from Cohort 2 patients, who subsequently had a confirmed diagnosis of PH, was used to identify PH comorbidities and their PH groups. PH comorbidities, identified by manual chart abstraction versus health administrative data using ICD codes, were compared. Based on manual chart abstraction of electronic records, PH patients were assigned to WHO Groups 1–4 by screening for PH comorbidities, as recorded in discharge notes/ED visit and clinic records, and pertinent clinical investigations/testing. Screened comorbidities included LHD (diastolic/systolic dysfunction,[22] mitral/aortic valve disease, cardiomyopathy), lung disease [(COPD-based off FEV1/FVC < 0.70 on spirometry,[23] interstitial lung disease, sleep-disordered breathing) and venous thromboembolic disease (based on CT pulmonary angiography and ventilation perfusion scan)]. Comorbidities for Group 5 PH were not explored given the low prevalence, the unclear and/or multifactorial nature, and the variable prevalence of PH despite clinical severity of the underlying condition, hence limiting the attribution of disease severity to PH.[24–26] To explore the presence of PH comorbidities versus clinical allotment of WHO PH Groups, this abstraction had two approaches: Abstraction A—assessing the presence or absence of any PH comorbidities and allocating patients to WHO Groups; and Abstraction B—identifying comorbidities that were most likely attributable to causing PH. This was a clinical adjudication based on available investigations, clinic, and discharge clinic notes. Assignment of multiple WHO PH groups to a single patient was permitted in both abstractions. This chart abstraction was also done by the same abstractors as the PH diagnosis abstraction (AH and TW). Discordance between chart diagnoses and investigations was resolved by consensus between the two reviewers.

Using ICD codes from health administrative data, patients with PH were also classified into WHO PH Groups based on comorbidities recorded up to 5 years before to 2 years after the index date (using CIHI-DAD and/or CIHI-NACRS) to match the manual chart abstraction time window. Diagnostic codes for LHD, lung disease and venous thromboembolic disease were used to identify patients in presumptive Groups 2–4, respectively (see Table S1 for ICD 9/10 for the specific codes used). Group 5 PH (miscellaneous) was not studied because its heterogeneity precludes accurate identification in these databases. Patients were eligible to be included in multiple PH groups except for Group 1, since Group 1 PH, by definition, should lack significant comorbidities that promote WHO Groups 2–4 PH. This method was employed as clinically even though we acknowledge the presence of mild LHD or lung disease in a patient that is thought to be Group 1; they are often excluded from Group 1 classification if the comorbidities are substantial. The group assignment by both chart abstractions (A and B) were then compared to the group assignment based on administrative codes. Abstraction A was compared with administrative codes as percentage congruence between WHO PH Groups 1–4. Abstraction B was compared to administrative codes for both exact matches and matches with at least 1 PH Group assignment, and percentage agreements were calculated using the patients with a confirmed diagnosis of PH as a denominator.

All analyses were performed at ICES using SAS software, version 9.2. This study was approved by the institutional review board at Sunnybrook Health Sciences Centre in Toronto, Canada and the Queen's University Health Sciences Research Ethics Board.

RESULTS

Description of the cohort

Three hundred clinic patients with an unknown diagnosis of PH from cardiopulmonary clinics (Cohort 1) and 200 patients with a possible diagnosis of PH (Cohort 2) were initially selected for inclusion. After excluding duplicates, the combined cohort consisted of 449 patients. Chart abstraction revealed that 88.5% (177/200) of patients with a presumptive diagnosis of PH (Cohort 2), based on hospital discharge code or ED code, had a verified and confirmed diagnosis of PH by chart abstraction. Of the 249 randomly selected, nonduplicate cardiopulmonary clinic patients, 28.5% (71/249) were found to have a diagnosis of PH by chart abstraction (Table 1). In total, 248 of the 449 (55.2%) patients had a verified diagnosis of PH. The mean (±SD) age of validated PH patients was 70.6 (±14.7) years. The majority of these patients were females (65.5%). The age and gender distributions were similar across patients with/without a diagnosis of PH. Based on the Charlson Comorbidity Index (CCI) score, patients with a diagnosis of PH were sicker than the balance of the cohort. For example, fewer

TABLE 1 Characteristics of patients with/without pulmonary hypertension identified through chart abstraction

Characteristic		Diagnosis of pulmonary hypertension		
		No $N = 201$	Yes $N = 248$	*p*-value
Age	Mean ± SD	70.27 ± 11.97	70.84 ± 16.59	0.68
Sex	Female	135 (67.2%)	159 (64.1%)	0.50
	Male	66 (32.8%)	89 (35.9%)	
Socio economic status quintile				0.81
	1	52 (25.9%)	63 (25.4%)	
	2	36 (17.9%)	53 (21.4%)	
	3	48 (23.9%)	52 (21.0%)	
	4	31 (15.4%)	42 (16.9%)	
	5	33 (16.4%)	35 (14.1%)	
Charlson comorbidity index	0	143 (71.1%)	108 (43.5%)	<0.001
	1	24 (11.9%)	61 (24.6%)	
	2	24 (11.9%)	29 (11.7%)	
	3+	10 (5.0%)	50 (20.2%)	

Note: Characteristics measured at index date.

patients with PH had a CCI score of 0 compared to those without PH (43.5% vs. 71.1%), while more patients with PH had a score of 3 or more compared to those without PH (20.2% vs. 5.0%) $p < 0.001$.

Validation of the diagnosis of PH

The diagnostic accuracy of administrative data was determined by comparing the diagnosis of PH, based on chart abstraction to our experimental health administrative algorithms (using hospitalization and/or ED visits based upon health administrative data), Table 2. Administrative data showing "one hospitalization" or "one hospitalization or ED visit" had a sensitivity of 73%, a specificity of 99% and an AUC over 0.85 for abstraction-confirmed PH.

Comorbidities for PH and WHO PH groups

When group assignment by chart abstraction (Abstraction A) for PH comorbidities was compared to administrative codes, 100% of Groups 1 and 4 and over 85% of Groups 2 and 3 of comorbidities were congruent (Figure 2). When Abstraction B was compared to administrative codes, there were exact matches of PH groups (either single or multiple PH Groups) in 30.5% of patients, and an additional 56.6% had at least 1 PH Group assignment (Table 3). Hence a total of 87.1% of patients had at least 1 PH Group assignment congruent between

chart abstraction and administrative codes. A larger proportion of patients were assigned to multiple PH groups based on administrative codes versus clinical group assignment (Abstraction B) [68% (121/177) vs. 17.5% (31/177) patients] $p < 0.001$.

DISCUSSION

To our knowledge, this is the first study validating the accuracy of hospital-based administrative data to identify patients with PH and to categorize those with PH into WHO PH group classification. To date, cohort information on PH is mainly limited to clinical registries with emphasis on Group 1 PH.[6,7,27–36] A major finding of the
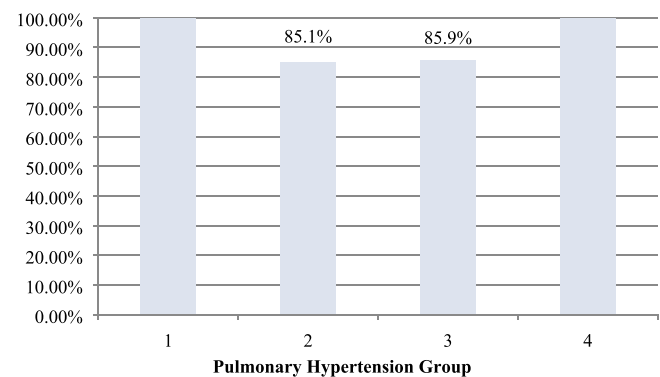

FIGURE 2 Percentage congruence for Pulmonary Hypertension comorbidities between chart abstraction (A) versus administrative codes

TABLE 2 Operational characteristics of different algorithms of hospitalization and emergency department visits to capture a diagnosis of pulmonary hypertension

Algorithm	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	AUC	LR +	LR −
1 Hospitalization with PH	73	100	99	75	0.8624	Inf[a]	0.27
	(67–0.78)	(97–100)	(97–100)	(69–80)			
1 ED visit	8	100	95	47	0.5378	Inf	0.92
	(5–12)	(97–100)	(76–100)	(42–52)			
1 Hospitalization or 1 ED visit with PH	73	99	99	75	0.8599	73	0.27
	(67–78)	(96–100)	(96–100)	(69–80)			
1 Hospitalization AND 1 ED visit	8	100	100	47	0.5403	Inf	0.92
	(5–12)	(98–100)	(83–100)	(42–52)			
Any 2 visits (Hospitalization or ED visits)	28	100	100	53	0.6391	Inf	0.72
	(22–34)	(98–100)	(95–100)	(48–58)			

Abbreviations: AUC, area under the curve; CI, confidence interval; ED, emergency department; LR, likelihood ratio; NPV, negative predictive value; PH, pulmonary hypertension; PPV, positive predictive value.

[a]Infinity (results from dividing by zero).

TABLE 3 Comparison of WHO PH comorbidities by chart abstraction (B) and by ICD codes using health administrative data

| | PH Group from Chart Abstraction | | | | | | | | Total |
	1	2	3	4	2,3	2,4	3,4	2,3,4	
PH Group from Administrative Data									
1	9	12	x	x	x	x	x	x	26
2	x	17	x	x	x	x	x	x	21
3	x	x	x	x	x	x	x	x	6
4	x	x	x	x	x	x	x	x	x
2,3	x	41	35	x	19	x	x	x	96
2,4	x	x	x	x	x	x	x	x	x
3, 4	x	x	x	x	x	x	x	x	0
2,3,4	x	9	x	x	x	x	x	x	22
Total	9	82	49	6	25	x	x	x	177*

Note: x-values less than ≤5 has been marked as "x" in keeping with privacy policy of the Institute of Clinical Evaluative Sciences, Ontario. PH, pulmonary hypertension. 177* includes patients from Cohort 2 with a conformed diagnosis of PH through chart abstraction. Green color denotes number of patients with an exact match of WHO PH Group assignment between chart abstraction and health administrative data (54/177 = 30.5%). Yellow color denotes number of patients with at least one WHO PH Group match between chart abstraction and health administrative data (100/177 = 56.6%).

current study is that 1 hospitalization or 1 ED visit with ICD codes used for PH in a health administrative data set is a sensitive and specific means to identify PH patients when using a physician chart review as the gold standard. This supports the use of these criteria in population studies. Furthermore, ICD-9 and ICD-10 codes can be used to identify the WHO group into which a PH patient best fits with reasonable accuracy.

The ICD codes used to identify PH are unique from other diagnoses. In our previous work, we have shown that code abstraction for PH from charts following hospitalization or ED visits has an accuracy of 100%.[3] PH diagnoses were correctly differentiated and identified as PH-relevant codes in all cases at abstraction.[3]

Several combinations of healthcare visits with ICD diagnostic codes of PH were explored in our study to evaluate what criteria most accurately identify PH patients. One hospitalization or ED visit had the best operational characteristics, with an AUC of 0.86. This is a pragmatic definition that can be used to identify patients with PH with reasonable accuracy.

There are limitations of the previous cohorts as they are predominately outpatient cohorts with a mix of PH clinic patients and real-world populations.[4,5] These studies also included PH therapies and RHC in their validation algorithms, information that is often sparse in population level administrative data limiting generalizability. Our study captures in-patient administrative data. These diagnoses are clinically significant enough to be coded as primary/secondary diagnoses, making our capture of diagnoses more robust and specific. This may explain better operational characteristics for identification of PH patients using our algorithm than was observed in prior studies that used more complex algorithms, which included PH therapies and procedures such as RHC.[4,5] Our method is pragmatic in that it uses readily available ICD codes. This is especially relevant for countries such as Canada, where ICD based coding is only captured in hospital based settings, as there are no specific Ontario Health Insurance Plan (OHIP) physician billing codes available for PH, which makes population-based, outpatient studies challenging for PH. Although the study setting was done in a location of PH expertize, the ICD codes that are captured are applicable throughout hospitals in Ontario.

We used a consistent 7-year time window to capture PH as a diagnosis both in manual chart abstraction and using administrative codes given the natural history of PH and the long time lapse from presentation to diagnosis.[21] This included a retrospective (up to 5 years) and prospective (up to 2 years) window, which allowed us to capture accurate and valid information on chart abstraction from the index date of the patient. We utilized the same 7-year window to identify PH comorbidities. The 5-year retrospective time window was consistent with our previous work.[3] The 2-year prospective window was chosen to provide a reasonable time frame to accrue a diagnosis of PH following the index date. This time window of (2010 to 2012) for cohort capture was used to include both ICD9 and ICD 10 codes to mirror the transition in Ontario electronic health records.

Within our combined cohort, more than half had a confirmed diagnosis of PH, making it an enriched cohort for validation purposes. The mean age was 70 years, and the majority were females, which is consistent with PH epidemiology. In a population-based study in Australia, Strange et al. reported a mean age of 75 years, with the majority being females (60%).[6] A study conducted in

Spain evaluated patients with PAH and CTEPH. The PAH group had a mean age of 45 years, while the CTEPH group had a mean age of 61-years.[7] The demographics in our validation study are consistent with these previous epidemiological studies with comparable age and gender distribution,[6,7,27–36] expanding the generalizability of our findings. In the current cohort, patients with a diagnosis of PH based on administrative codes were sicker, based on their higher CCI scores, than patients without PH. This was also consistent with previous work done by our group that showed a diagnosis of any form of PH increases 1-year standardized mortality rates 7.1-fold relative to patients without PH.[3]

Several other chronic cardiopulmonary diseases have been studied using health administrative data, notably asthma and COPD. For asthma, two or more ambulatory care visits and/or one or more hospitalization/s has a sensitivity of 83.8% and a specificity of 76.5%, based on comparison with the gold standard of chart review.[11] In another study that compared case identification by administrative databases, using a single OHIP claim for asthma, sensitivity was 91.4% and specificity 82.9%.[37] The most sensitive health administrative definition of COPD was 1 or more OHIP claims and/or 1 or more hospitalizations for COPD. This criterion yielded a sensitivity of 85.0% and a specificity of 78.4%.[10] Our validated algorithm for PH has very comparable operational characteristics (sensitivity: 73%; specificity: 99%) and employs similar methodology.

Our efforts to validate the use of PH comorbidities to categorize PH patients into WHO groups yielded at least partial WHO Group congruence in up to 87% of patients when a clinical adjudication of PH Groups were compared to administrative codes. Administrative data, however, tended to allocate more patients to multiple PH comorbidities. Our previous work using population level health administrative data to capture PH and WHO PH groups showed that over a third of adult patients with PH belonged to more than one WHO PH group, with the most frequent overlap diagnosis being Groups 2 and 3 (29.3%).[3] Even in registries, such as REVEAL, created in specialized Group 1 PH-focused studies, where all patients are assessed and classified by a PH expert physician, multiple comorbidities, including COPD and sleep apnea, are common.[38] This highlights the fact that PH Group allocation is often based on physician attribution gauging the severity of a comorbidity and other clinical parameters and weighing the impact on the development of PH. This may also be explained by administrative databases deriving diagnosis from multiple healthcare contacts within a window versus chart abstraction, which is more integrative based on information available at that encounter. Classifying patients into WHO groups based on PH comorbidities using administrative data is helpful to identify the patient's PH risk profile. This highlights the likelihood that a large majority of patients have more than one PH comorbidity. The overlap between Group 2 and Group 3 PH is certainly not surprising since LHD and chronic lung diseases like COPD have very similar predisposing risk factors, such as cigarette smoking and obesity. The use of administrative codes offers the opportunity to classify patients into WHO PH Groups 2–4. Hence, we propose the WHO PH comorbidity classification be used to identify risk factors and to describe the phenotype of PH patients and their PH Groups.

There are several strengths to our study. To our knowledge, this is the first validation study of health administrative data used to identify PH. This included over 200 patients with a confirmed diagnosis of PH out of a total of almost 450 patients. Chart abstraction was done meticulously by two clinicians independently to confirm or refute the diagnosis of PH to use as a reference standard. Our previous work using similar diagnostic codes described temporal trends and epidemiology of PH that was consistent with other published literature on PH.[3]

A limitation of this study is that it was conducted at one hospital site. However, its generalizability is unlikely to be compromised as chart abstraction was done manually by qualified clinicians and was compared to administrative data that is uniform across the province of Ontario, Canada. However, we acknowledge that this is a single center proof of concept study with potential for referral bias. We recommend external validation cohorts for more generalizability.

In conclusion, this study validates the utility of a diagnosis of PH using administrative databases to identify cases of PH for population-based epidemiologic studies. It also highlights the importance of identifying PH comorbidities in grouping PH patients into different WHO groups. Identification of PH patients at a population level enables the study of real-world patient outcomes in this chronic disease, which has significant disease burden with increasing incidence.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.

ETHICS STATEMENT

This study was approved by the institutional review board at Sunnybrook Health Sciences Centre in Toronto, Canada and the Queen's University Health Sciences Research Ethics Board.

AUTHOR CONTRIBUTIONS

Don Thiwanka Wijeratne: Developing concept and methods, data abstraction, manuscript writing and editing. Ahmad Housin: Data abstraction, manuscript writing and editing. Katherine Lajkosz: Data analysis, manuscript writing and editing. M. Diane Lougheed: Developing concept and methods, manuscript writing and editing. Ping Yu Xiong: Developing concept and methods, manuscript writing and editing. David Barber: Data extraction, analysis, manuscript writing and editing. Katharine M. Doliszny: Developing concept and methods, manuscript writing and editing. Stephen L. Archer: Developing concept and methods, manuscript writing and editing.

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