Prediction of the rate of hand injuries in Singapore

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Research Article

Keywords: Demand, Supply, Labor, Health

Posted Date: August 26th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-806073/v1>

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Abstract

Purpose

This study aims to analyze the correlation between the incidence rate of hand injuries and various construction and manufacturing indicators in Singapore. We hypothesize that the number of hand injuries is correlated to activity in the construction and manufacturing industries in Singapore.

Methods

20,764 patients who underwent hand surgeries in a tertiary institution between 2012 to 2018 were reviewed. Two independent, blinded observers extracted the frequency of hand surgeries performed from Electronic Medical Records. Economic indicators pertinent to Singapore's labor force, construction and manufacturing industries were collected and smoothed by simple moving average of the prior 3 months. Results were analyzed using IBM SPSS v25.0.

Results

Significant independent univariate variables were Purchasing Manager Index for Manufacturing and Industrial Production Index. Multivariate regression of quarterly reported figures showed that Purchasing Manager Index for Manufacturing, Construction Index, Labor Productivity Change for Gross Domestic Product and Labor Productivity Change for Manufacturing were significantly correlated with hand injuries, with $r^2 = 60.9\%$.

Conclusion

Quarterly economic indicators from construction and manufacturing industries can be used to predict the incidence of hand injuries with a 60.9% correlation. These findings may be useful for anticipating healthcare resource allocation to treat hand injuries.

Type of Study and Level of Evidence

Economic and decision, Level II.

1. Introduction

Hand injuries are frequently encountered by doctors involved in trauma care.¹ Studies in the Emergency Department (ED) have shown that hand injuries comprise up to 10% of the visits and range from simple lacerations or finger sprains to mutilating injuries or amputations.² The high incidence rate of hand injuries in Singapore is not limited to those that present to emergency departments. AIG Asia Pacific Insurance Pte. Ltd analyzed 3,500 claims in a 12-month period and found that hand injuries accounted for 36% of the overall claims reported. In contrast, slip, trip and fall accidents contributed 24%.³ Hand injuries make up a significant percentage of acute injuries in Singapore and form the most common traumatic occupational injury.⁴

Various studies have evaluated the epidemiology of wrist and hand injury in numerous countries. Burrridge JD et. al. reported that the occupations in New Zealand with the highest rate of hand injuries are machine operators, construction, forestry workers and meat processing workers. Michal Grivna et al.⁵ found that hand injuries constitute

7%-28% of all injuries in the United Arab Emirates (UAE)^{6,7}, and account for approximately 20% of all emergencies presenting to hospital emergency departments.⁸ Polinder S. et al. found that in the Netherlands, 42% of all emergency department visits were due to upper extremity injuries, of which injuries to the wrist and hand were the most common.⁹

Construction and manufacturing industries are the highest contributors of hand injuries. AIG Asia Pacific Insurance Pte. Ltd reports that 35% of the total annual claims value was incurred by workers in the construction and manufacturing trade.³ Hey et al. studied 504 patients admitted to the ED (National University Hospital (NUH) Singapore) with hand injuries over a course of three months and found that 43% of these patients suffered from industrial injuries, comprising of lacerations and crush trauma.¹⁰

If there is a significant correlation between hand injuries and activity in the construction and manufacturing industries, a fluctuation in the labor force of these industries may intuitively cause the number of hand injuries to fluctuate correspondingly. Singapore's labor workforce is flexible, with the total labor force fluctuating over the years. The Report on Labor Force in Singapore by the Ministry of Manpower details that between 1994 to 1996, the percentage change year on year was 4.5–5.04% to 15.75% respectively; and from 2000 to 2002, the percentage change was –0.74–6.3% to –0.42% respectively.¹¹ Moreover, as Singapore has long counted on its people as its biggest resource, Singapore's economy is heavily dependent on foreign labor, particularly in blue collar jobs. There are 1,382,900 foreign workers (36% of Singapore's total labor force), of which approximately 300,000 of them are in the construction industry¹², while 50% of the manufacturing industry are foreign workers.¹³

Workers in sectors requiring manual labor, in particular the construction and manufacturing industry, tend to face a higher risk of suffering from hand injuries. Grivna et al. found that in the UAE, workers in the construction industry were at a higher risk of suffering hand injuries. Hand injury rates of workers operating machinery was 51.1% compared to heavy objects (27.7%), traffic (0%) and animal (0%).⁵

To the author's knowledge, no studies have been conducted to evaluate the correlation between the incidence rate of hand injuries and manpower in the construction and manufacturing industries in Singapore.

Our study aims to analyze the correlation between the incidence rate of hand injuries and manpower in the construction and manufacturing industries in Singapore. We hypothesize that economic indicators in the construction and manufacturing industries are directly correlated to the rate of hand injuries.

2. Methods

Twenty thousand, seven hundred and sixty-four consecutive patients who had undergone Hand & Reconstructive Microsurgery (HRM) surgeries in a single tertiary trauma institution between January 2012 and December 2018 were included in our retrospective study.

A non-observer team member extracted the relevant patient data from the Electronic Medical Records and performed de-identification of data. The study was performed by two independent observers who were blinded to the patient identifiers.

Various economic markers that were pertinent to Singapore's labor force, construction and manufacturing industries were used for this study, as shown in Table 1. These economic indicators were collected and published online by Singapore government agencies. The various economic indicators were smoothed by a calculation of simple moving average of the prior 3 months.

Table 1
List of economic markers relevant to Singapore's labor force, construction and manufacturing industries.

Economic marker	Abbreviation	Source	Frequency
Manufacturing Index	MI	CEIC Data, Department of Statistics	Monthly
Construction Index	CI	CEIC Data, Department of Statistics	Monthly
Total Manufacturing Output	TMO	CEIC Data, Department of Statistics	Yearly
Purchasing Manager Index	PMI	Singapore Institute of Purchasing and Material Management	Monthly
Labor Productivity Change for Gross Domestic Product	LPCgdp	Ministry of Trade and Industry	Quarterly
Labor Productivity Change for Manufacturing	LPCmanu	Ministry of Trade and Industry	Quarterly
Labor Productivity Change for Construction	LPCcons	Ministry of Trade and Industry	Quarterly
Composite Leading Index	CLI	Ministry of Trade and Industry	
Construction Contracts Awarded	CCA	Building and Construction Authority	Monthly
Contracts Awarded	CA	CEIC Data, Department of Statistics	Yearly
Change in Value Added per worker per actual hour worked for Manufacturing	CVAmanu	CEIC Data, Department of Statistics	Yearly
Change in Value Added per worker per actual hour worked for Construction	CVAcons	CEIC Data, Department of Statistics	Yearly
Industrial Production Index	IPI	Singapore Economic Development Board	Monthly

IBM SPSS software version 25.0 was used for data analysis. Chi Square test was performed to compare the various economic indicators against incidence rate of hand injuries. Statistical significance was defined as p-value < 0.05.

This study was approved by an Institutional Review Board.

3. Results

Demographics

73.68% of our patients were between 21 to 60 years old. There was a male predominance 71.57%, and 53.69% of our patients were Chinese (Table 2).

Table 2
Demographics of 20, 764 patients according to age, gender, nationality and race.

Percentage (%)	
Age (years old)[#]	
1 to 20	9.77
21 to 40	42.13
41 to 60	31.55
61 to 80	15.44
80 to 98 [^]	1.11
Gender	
Male	71.57
Female	28.43
Nationality	
Singaporean	58.79
Non-Singaporean	41.21
Race[%]	
Chinese	53.68
Malay	11.59
Indian	15.58
Others	19.14
[#] Mean age is 40.93 years old	
[^] Oldest patient is 98 years old	
[%] The “CMIO model” is the dominant organizing framework of race in Singapore ^{14,15}	

Univariate and Multivariate analysis

The results for the univariate analysis and multivariate linear regression analysis conducted via SPSS to analyze the correlation between the various economic variables and the incidence rate of hand injuries is shown in Table 3.

Table 3
Univariate and Multivariate analysis of various economic indicators

	Univariate analysis		Multivariate analysis	
	R square (%)	p value	R square (%)	p value
Quarterly				
Purchasing Manager Index for Manufacturing	0.161	0.034*	60.9	0.001*
Construction Index	0.020	0.471		
Labor Productivity Change (GDP)	0.024	0.427		
Labor Productivity Change (Manu)	0.073	0.165		
Labor Productivity Change (Cons)	0.024	0.429	-	-
Industrial Production Index	0.132	0.057	-	-
Manufacturing Index	0.004	0.757	-	-
Monthly				
Purchasing Manager Index for Manufacturing	0.084	0.008*	-	-
Construction Index	0.009	0.390	-	-
Construction Contracts Awarded	0.321	0.011*	0.48	0.005*
Industrial Production Index	0.070	0.016*		
Manufacturing Index	0.003	0.637		
*: Significant values (p < 0.05)				

Univariate analysis showed that the correlations were significant (p < 0.05) between incidence rate of hand injuries and quarterly PMI (r = 0.161, p = 0.034), monthly PMI (r = 0.084, p = 0.008), monthly IPI (r = 0.070, p = 0.016) and monthly CCA (r = 0.321, p = 0.011).

Multivariate linear regression showed that the combination of economic variables in the quarterly analysis of PMI, CI, LPCgdp and LPCManu gave a combined highest significant (p < 0.05) R square value of 0.609, or 60.9%. For monthly comparison, IPI and CCA were significant (p < 0.05) independent variables for the incidence of hand injuries, yielding a R square value of 0.480 or 48.0%.

Equation

An equation to predict the number of hand injuries was derived including all four significantly independent economic variables using the quarterly analysis:

$$\text{Number of hand injuries} = 22.9 (\text{PMI}^d) + 2.77 (\text{CI}^e) - 36.7 (\text{LPCgdp}^f) + 6.88 (\text{LPCmanu}^g) - 4033$$

Legend:

^dPMI: Purchasing Manager Index for Manufacturing

^eCI: Construction Index

^fLPCgdp: Labor Productivity Change for Gross Domestic Product

^gLPCmanu: Labor Productivity Change for Manufacturing for Manufacturing

Variables were smoothed to simple moving average of 3 months

4. Discussion

The Singapore economy is susceptible to global economic activity. It is a small island state with a lack of natural resources.¹⁶ At the outset of industrialization in the 1960s, the country depended on foreign direct investment from multinationals in labor-intensive manufacturing industries to secure the requisite markets, technical knowledge and management expertise.¹⁷ Over the years, openness to trade and investment allowed Singapore to raise its productive and technological capabilities, transforming the state into a high value-added manufacturing node in regional production networks.¹⁷ As an export driven economy reliant on global trade, Singapore's Gross Domestic Product (GDP) has seen both expansion and contraction over the years with GDP growth (annual %) fluctuating 4.46% (2012), 4.84% (2013), 3.94% (2014), 2.99% (2015), 3.24% (2016), 4.34% (2017), 3.44% (2018).¹⁸ The Straits Times Index (STI), a market capitalization weighted index that tracks the performance of the top 30 companies listed on SGX¹⁹ also fluctuates: 7.92% (2012) to 4.78% (2013) to 12.79% (2014) to -14.06% (2015) to -7.45% (2016) to 9.00% (2017) to 8.06% (2018).²⁰

Singapore's labor force has seen fluctuation across the years. The Report on Labor Force in Singapore by the Ministry of Manpower details that between 1994 to 1996, the percentage change year on year was 4.5–5.04% to 15.75% respectively.¹¹; and from 2012 to 2018, the percentage change was 3.71–2.38% to 2.47–2.21% to 1.69% to -0.43–0.51% respectively.²¹ In 2018, Singapore's Ministry of Manpower's reported in their labor force findings that the total labor force stood at 3,675,600, with the employment rate being 97.3% (3,575,300).¹¹ The resident labor force at that time was 2,292,700, with a median age of 43 years old and labor force participation rate of 67.7%.²² With a high employment rate of 97.3%, economic indicators such as the Straits Times Index (STI) and Gross Domestic Product (GDP) performed well for that year, with the 2018 economy expanding by 1.9 per cent from 2017.²³ Singapore's gross domestic product (GDP) is the most important measure to evaluate the performance of Singapore's economy.²⁴

Labor force fluctuations also occur internationally. The countries with the smallest fluctuation in labor force are part of the European Union (EU). From 2012 to 2018, The European Union faced an average percentage change in labor force of 0.37%, with Italy, France and Germany experiencing 0.47%, 0.70%, 0.80% respectively²⁵. In comparison, Singapore experienced 1.50% change²⁶, a figure which is more than its Asian counterparts Japan (0.66%) and Korea (1.32%)²⁵. The comparatively smaller fluctuations in the labor force of the EU with Singapore can perhaps be attributed to the EU's employee centric employment laws, making it more difficult to lay off workers.²⁷ Whereas Singapore is more employer centric.²⁸

In Singapore, hand injuries make up a significant portion of acute injuries²⁹, many of which are sustained in the industrial workplace. In 2020, there were 46 out of 463 (9.34%) cases where workers lost their hands or fingers in amputation accidents.^{30,31} The number of hand injuries would fluctuate with fluctuations in the total number of labor force in a country.

Formulation of equation

Indeed there are multiple correlations of Singapore's hand injuries with economic indicators. Significant ($p < 0.05$) multivariate variables were PMI, CI, LPCgdp, LPCmanu, which yielded 60.9% R square, p value 0.001 in the quarterly analysis. In the monthly analysis, significant ($p < 0.05$) multivariate variables were IPI and CCA which yielded a R square value of 0.480 or 48.0%.

PMI is a measure of the prevailing direction of economic trends in manufacturing, summarizing whether market conditions from the perspectives of managers are expanding, staying the same or contracting.^{32,33,34} CI indicates the level of economic activity in the Construction sector.³⁵ LPC indicates whether output is increasing or decreasing per worker.^{36,37} Greater productivity describes being able to do more in the same amount of time, this in turn frees up resources to be used elsewhere.

An equation to predict the number of hand injuries was derived including all four significant economic variables using the quarterly analysis:

$$\text{Number of hand injuries} = 22.9 (\text{PMI}) + 2.77 (\text{CI}) - 36.7 (\text{LPCgdp}) + 6.88 (\text{LPCmanu}) - 4033$$

How to use the equation

The equation is used in the following way: To predict the number of hand injuries, using the economic indicator of PMI as an example, keeping all others constant, if PMI goes up by 1%, there will be a 22.9 increase in the number of hand injuries.

Strengths

To the authors' knowledge, this paper represents the first paper to analyze the correlation of economic factors against the number of hand injuries. In our data, there is a relatively high proportion of foreign patients (41.21%) that undergo hand surgeries. As of 2018, the total foreign workforce in Singapore stood at 1,386,000 (24.58% of the entire population). However, they are usually under-represented in studies. In this study, we present a large cohort of foreign patients, compared to the national proportion.

The clinical implications of the study may allow us to forecast the clinical resources required to treat hand injuries from the construction and manufacturing industry in relation to economic indicators.

Limitations

We identified a few limitations in our study. Firstly, surgical factors. We used the incidence rate for hand surgeries as a proxy for the incidence rate for hand injuries. These hand surgeries included both elective and emergency operations and therefore may not be reflective of patients who presented with hand injuries but did not undergo hand surgeries. However, our large sample size of 20,764 patients is likely to account for exceptions pertaining to these cases. Hand injuries are typically emergency injuries such as lacerations and crush trauma; but our data combines both. Fortunately, elective operations are not known to fluctuate much. For example, trigger finger operations are not known to fluctuate from month to month.^{38,39,40} Since we have found in our results there is a significant correlation between the incidence of hand injuries and economic indicators, an extrapolation between two time points effectively nullify the electives, leaving the emergencies to account for the cause of fluctuations.

Secondly, our tertiary institution covers referrals from the south and western regions of Singapore where a higher proportion of construction and manufacturing industries are located. Hence, there may be a higher proportion of hand injuries that may present to our institution as opposed to other local tertiary institutions. However, this allows us to have an increased sensitivity to the fluctuations in hand surgeries done emergently in response to fluctuations in the labor force.

Lastly, factor selection. Some of the factors used in our study were not reported in a timely fashion. For example, PMI is reported monthly, because companies use it to purchase equipment but others such as CI was published one year later. Therefore, the reporting time lag of the economic variables may dampen the usage of our equation as a timely method of forecasting.

In conclusion, a correlation of 60.9% (p value = 0.001) was found between the number of hand injuries and the following economic indicators: PMI, CI, LPCgdp and LPCmanu for hand injuries from 2012 to 2018. These findings may enable us to forecast clinical resources required to treat hand injuries from the construction and manufacturing industry in relation to economic indicators.

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

Data may be made available upon reasonable request

Competing interests/Conflicts of Interest

There are no conflicts of interest to declare.

Funding

This study was not funded.

Acknowledgements

Authors' contributions: GZQ Liao and AEJ Cheah conceptualised the research question and design of the manuscript. GZQ Liao, WX Tay, JYS Wong and JY Weng contributed to the design of the study, analysis and interpretation of data. All authors contributed to manuscript drafting and revision. All authors read and approved the final version of the manuscript. Nil funding was obtained for this study.

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