SPECIAL ARTICLE

An Intense Influenza Pandemic – Possible Subtype of H5N1
Its Implications for Jamaica

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ABSTRACT

Using two different attack rates, 20% and 30%, the paper attempts to project several possible outcomes for the Jamaican economy in the event of a severe pandemic. In addition to forecasting the possible loss in man hours for the economy, the study uses the Monte Carlo modelling technique to provide estimates of the death and hospitalization rates among the 0–19, 20–64 and 65^{+}-year age cohorts while extra-polating the demand for healthcare providers.

Keywords: Pandemic, vaccine, man hour, infection, virus, flu

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RESUMEN

A partir de dos tasas de ataque diferentes – 20% y 30% – el presente trabajo persigue dar una proyección de varios posibles resultados para la economía jamaicana en caso de una pandemia severa. Además de pronosticar la posible pérdida en horas-hombre para la economía, este estudio usa la técnica de modelación Monte Carlo para dar estimados de las tasas de muerte y hospitalización entre las cohortes de 0–19, 20–64 y 65+ años de edad, mientras que extrapola la demanda de proveedores del cuidado de la salud.

Palabras claves: Pandemia, vacuna, hombre-hora, infección, virus, gripe

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INTRODUCTION

Although an influenza outbreak is a natural and recurring event, the outbreak of a severe influenza pandemic is an uncommon phenomenon that is accompanied by many unknowns. An examination of available historical records confirms that over the last century, there were only three intense global flu pandemics: the "Spanish Flu (H1N1 virus)" of 1918, the "Asian Flu (H2N2 virus)" of 1957 and the "Hong Kong Flu" (H3N2 virus) of 1968 (1). In the intervening years, however, there were several other milder flu epidemics, including *Severe Acute Respiratory Syndrome* (Sars) and the Avian flu. Of these two, the Avian flu is of the greatest concern because it seems to have the potential to develop into a powerful disease which may result in the next intense global pandemic (2).

To trigger a worldwide pandemic, the influenza virus must possess three essential properties: the ability to infect humans, the ability to undergo a substantial change in its genome and the ability to transfer itself from human to human (3). To date the Avian flu virus, a subtype of the influenza A virus (H5N1), has not developed the capability to effect a human-to-human transfer. The greatest concern, as argued by Ruef (4), is that the highly pathogenic Avian flu virus, which is extremely lethal, could through continuous adaptation and mutation overcome this limitation and emerge as the next deadly pandemic virus. It is now a generally

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accepted view among a growing body of researchers that major pandemics have a 10–40-year life cycle (5) with the last one occurring in 1968, many scientists are of the belief that the next pandemic is not only imminent but is expected to have a devastating global reach (6). Because it is normally associated with a low fatality rate (0.1–2%), the flu virus is not considered the most lethal of infectious diseases but it is uniquely different from other viruses as it normally displays an exceptionally high attack rate (7). As a consequence, a severe pandemic, that is one with a high attack rate, coupled with a soaring morbidity rate would set the stage for social dislocation and negative macro-economic effects on national economies.

According to published estimates by the World Bank (8), the occurrence of a severe flu pandemic could push the world economy into a state of recession resulting in a contraction of global gross domestic product by approximately US$3 trillion while the projected death toll is put in the region of 71 million.

In any pandemic analysis, two types of impact are usually evaluated; one relates to the capacity of the prevailing medical infrastructure to effectively respond to the additional demand for healthcare services while the other speaks to the negative macro-economic consequences. Several researchers, including *Bell* and *Gersbach* (9), *Almond* and *Mazumder* (10), subscribe to the view that a pandemic has negative short term effects on the labour force which then percolates throughout the wider economy. The actual size of this impact depends largely on the extent to which the economy is organized and prepared to deal with this exogenous shock.

Jamaica is a major tourist destination hosting in excess of 2 million stop over visitors and cruise ship passengers, annually (11). The sheer volume and the diversity of source markets from which tourists originate make the country extremely susceptible to the devastating effects of a pandemic disease. This paper therefore seeks to explore and measure several possible impacts of such a pandemic (H5N1) on Jamaica. The study, however, begins with a general discussion of the assumptions on which the analysis is predicated. In the penultimate section, the paper uses the Monte Carlo simulation technique to derive expected levels of mortality, hospitalization, the level of infection rate for the general population and the demand for healthcare providers.

Base Line Assumptions and Data

The study will evaluate the potential impact of a pandemic using two possible attack rates most likely and a pessimistic rate which are ultimately determined from the rates assigned to the different sectors of the Jamaican economy. It uses a ten-sector disaggregation of the economy; four sectors are classified as goods producers while the remaining six are identified as service providers (Table 1). Given the diverse nature of sectoral activities, the immediate challenge was to establish a basic criterion that could serve as a benchmark to determine the attack rate that should be assigned to each sector. The allocated rates which are displayed in Table 1 were largely determined by the perceived level of human-to-human interaction at the work place and, by extension, the degree to which the work force is exposed to the disease.

Table 1: Sectoral output, employment and attack rate

Sector	**2007 Output**	**2007 Employment**	**Projected**	
	000 US ($)	000's	Sectoral Attack Rates Scenario I	Scenario II
Goods-producing sector	1207.82	**402.6**		
Agriculture, forestry, Fishing	188.56	207	15.00%	22.5
Mining	195.74	8.2	15.00%	22.5
Manufacturing	446.45	69.4	25.00%	37.5
Construction and installation	377.07	118	20.00%	30
Services sector	2537.86	**732.2**		
Transport, storage and Communication	503.43	78.6	30.00%	45
Financing, insurance, Real Estate and business Services	521.55	66.8	25.00%	37.5
Community, social and Personal services	339.1	317.2	20.00%	30
Electricity gas and water	145.45	7.7	15.00%	22.5
Wholesale and retail, Hotels and restaurant services	1028.33	261.9	30.00%	45
Industry not specified	335.91	**2.2**	5.00%	7.5
			Economy Average	
Total	**4081.59**	**1137**	**20%**	**30%**

Source: Employment and output data, Planning Institute of Jamaica

Because of the close interactive nature of work activities in the "Wholesale and Retail, Industry, Hotels and Restaurants" and "Transport, Storage and Communication" sectors, it can be argued fairly easily that workers in these industries would have a higher than average level of exposure and, by implication, a greater risk of contracting the virus. In the event of a pandemic, these sectors are likely to be the most affected and, hence, the decision to apportion the highest attack rates to them.

Although it is generally recognized that workers in certain service-oriented industries are more susceptible to communicable diseases because of high human-to-human contact, the manufacturing work force, because of confined work spaces, is also highly vulnerable to an infectious virus. This is the rationale for giving this sector an equal rating with "Financing, Insurance, Real Estate and Business Services". Except for "Community, Social and Personal Services," the remaining sectors were assigned much lower exposure rates based on the perception of lower level of human-to-human contact (Table 1). Overall, the most likely (20%) and a pessimistic (30%) attack rates for the wider economy were obtained as simple averages from the sectoral rates for each of the scenarios examined.

It is difficult to predict the severity of an influenza pandemic but it is possible to examine past experiences to provide insight into what to expect in the future. An examination of the historical records of past pandemics reveals that the attack rate for the Spanish flu (H1N1 strain) was 20% while estimates for the Asian flu (H2N2) and the Hong Kong flu (H3N3 strain) ranged between 25%–30% and 20%–35%, respectively (12). Against this backdrop, the presumed economy-wide rates adopted by this study are well within and, in instances, consistent with either the lower or upper limits of the rates connected to these three major pandemics. The paper is further circumscribed by several other assumptions, including a loss of ten working days (two weeks), the period when the pandemic is expected to be most intense.

An influenza pandemic normally strikes in several waves. The 1918 pandemic occurred in three waves while the 1857 and 1968 pandemics were characterized by two waves each (13), typically, the most intense of these waves last for approximately two weeks, usually occurring during the fourth and eleventh weeks from the start of the pandemic (14). This is the phase of the epidemic for which the economic impact of a potential pandemic on the Jamaican economy is measured.

When estimating the economic effect, in many instances, a separation is made between the demand and supply shock of the disease (15). The emphasis of this analysis, however, in part, will be on the supply effect, *ie*, measuring the loss in man hours. The demand effect comes about as the population takes precautionary measures, *ie*, initiating changes in consumption patterns and forms of socialization, to avoid infection. This study assumes that non-infected persons will not stay away from work in significant numbers because of the onerous economic burden many households may face from a loss in income. Obviously, if people were to stay away from work in larger numbers than anticipated so as to prevent infection then the effect on the work force will be much higher than is estimated by the study. In addition, given the recent decision by government to re-introduce free healthcare for the general population, it is presumed that medical costs will be covered through government transfer of funds to public health facilities, *ie*, clinics and hospitals, to meet the additional demand shock that will be placed on these institutions.

Although there is no uniformity in positions advanced by experts, there is little doubt that a severe pandemic may have some adverse influence on international trade. While some argue that a total ban on export activities from affected countries is highly unlikely, others do not rule out this possibility (16). It is strongly believed that if the H5N1 virus were to emerge as a possible pandemic then severe limitations may be placed on passenger and cargo modes of transportations which will represent a *de facto* ban on import and export activities. This not withstanding, the final assumption of the study is that, while some disruption/slow down in international trade is to be expected, the trade shock to production would be marginal. This posture is largely based on the position espoused by the World Health Organization, which supports the non-closure of international borders in the event of a pandemic (17). Recent action taken by the US government to keep its border with Mexico opened, in spite of the outbreak of swine flu, seems to lend support to this stance.

Labour Market Impact

Results on the number of workers that could be infected and the corresponding losses in man hours by sectors are presented in Table 2. The projections show that approximately 256.9 (000) persons or approximately 22.6% of the work force will contract the virus under the most likely scenario while for the worst case, some 385.2 (000) or 33.9% of the employed will be infected (Table 2).

Consistent with a *priori* expectations, the brunt of the labour force shock will be carried by the service sectors which are expected to account for approximately 71% of all infected workers while only 29% will originate from the goods-producing sectors. Two sectors in particular, "Wholesale and Retail, Hotels and Restaurants," and "Community, Social and Personal Services," will be the main drivers of the shock, as together, they will be responsible for 55% of the infected work force. If "Transport, Storage and Communication," which is normally deemed a high human contact sector, were to be included, then, the three sectors would generate a little over 64% of those workers that are expected to contract the disease. Among the goods-producing sectors, "Agriculture, Forestry and Fishing" will lead the charge with some 31.1% or 46.6 (000) infected workers.

Table 2 which also provide a sectoral breakdown of the anticipated losses in man hours, reveal a similar distri-bution profile as in the case of affected workers. The service sectors, especially "Wholesale and Retail, Hotels and Restaurants Services" and "Community, Social and Personal Services" will suffer huge losses in labour inputs (11–16 million man hours) which obviously will lead to a massive contraction in sectoral activities due to the absence of sick workers.

Mortality and Hospitalization Rates and Demand for Healthcare Workers

Thus far the study has assessed and analysed the effect of a pandemic shock on the supply of labour input. The objective in this section is to provide country-wide estimates on the several anticipated health outcomes including the mortality and hospitalization rates, as well as, the demand for healthcare workers.

Since it is difficult to ascertain the exact magnitude and behaviour of the next pandemic virus, the major challenge was to select an appropriate model to derive these estimates. The mathematical modelling of a phenomenon like a flu pandemic which is characterized by random changes that involve a significant level of uncertainty, is best approached

Table 2: Projected loss in man hours

Sectors	Employment at 000's	Attack Rate %	Infected Workers 000's	Man hours Loss (000)	Attack Rate %	Infected Workers	Man hours Loss (000) 000's
		Scenario I			Scenario II		
Goods-Producing sector	**402.6**						
Agriculture, Forestry, Fishing	207	15	31.1	2488 (12.1%)	22.5	46.6	3726 (12.1%)
Mining	8.2	15	1.2	96 (0.005%)	22.5	1.8	147.6 (0.005%)
Manufacturing	69.4	25	17.4	1392 (6.8%)	37.5	26	2082 (6.8%)
Construction And Installation	118	20	23.6	1888 (9.2%)	30	35.4	2832 (9.2%)
Services Sector	**732.2**						
Transport, Storage and Communication	78.6	30	23.6	1888 (9.2%)	45	35.4	2829.6 (9.2%)
Financing, Insurance, Real Estate and Business Services	66.8	25	16.7	1336 (6.5%)	37.5	25.1	2004 (6.5%)
Community, Social and Personal Services	317.2	20	63.4	5072 (24.7%)	30	95.2	7612.8 (24.7%)
Electricity Gas and Water	7.7	15	1.16	92.8 (0.005%)	22.5	1.7	138.6 (0.005%)
Wholesale and Retail, Hotels and Restaurant services	261.9	30	78.6	6288 (30.6%)	45	117.9	9428.4 (30.6%)
Industry not Specified	**2.2**	5	0.11	8.8 (0.0004%)	7.5	0.2	13.2 (0.0004%)
Average Attack Rate		20			30		
Total	**1137**		**256.9**	20,549.6		385.18	**30814.2**

Source: Employment, Planning Institute of Jamaica: Calculation was done using 8 hour day for 10 working days

through the use of the Monte Carlo simulation technique. The central thesis of the Monte Carlo modelling approach is to use random samples of variables/inputs to discover how a complicated process will behave. The technique attempts to choose from a myriad of probability distributions one that closely approximates the current state of knowledge about the phenomenon.

As a consequence, it is important to establish what is the current state of knowledge (research findings) on earlier pandemics in an effort to determine the input values that will be assigned to the health outcomes across three demographic groups, *ie* 0–19, 20–64 and 65^+ years, under both scenarios considered by the paper. Research thus far has revealed that the actual fatality rates for the two previous pandemics were: Asian Flu: < 0.2%; Hong Kong Flu: < 0.2% (18).

A death rate of 0.4% has now been projected as the most likely outcome for the current swine flu epidemic which has been recently elevated to a pandemic status by the World Health Organization (19). The mortality rates in all three pandemics are depicted as a category II (*ie* when the clinical fatality rate is between 0.1% and 0.5%) on the pandemic severity index (20). The relatively high fatality rate assigned to the current pandemic is based largely on limited global vaccine production capacity, as well as the time required after the virus strain has been identified to develop an effective vaccine. This study assumes that there will be a 4 in 1000 fatality rate or, put differently, the clinical fatality rate will be 0.4%, which is well within the realm of possibilities.

Currently, there are no estimates of the hospitalization rate for any of the past epidemics. Many countries/organizations, however, have incorporated different assumed rates in their pandemic plans. Examples of rates used include: WHO: 0.6–2.2%, European Union: 1%, CDC Flu Aid: 2.5%, Germany: 1.5%, Mexico: 10%, (21). The paper assumes a 1% hospitalization rate which may be considered low but well within the rates assumed by these plans.

Monte Carlo Simulation

Results of the Monte Carlo simulation for each scenario are presented in Tables 3 and 4. Each Table provides the absolute number as well as the percentage breakdown of expected deaths and hospitalization across the age groups and the level of infection within the general population. In terms of death and hospitalization, the greatest impact (86%) is projected to be within the 20–64 and the 65^+ year age cohorts. Projecting across both scenarios, the results further reveal that some

Table 3: Monte Carlo Simulation

Total cases at risk (20%)			
Catergory	Age group	Population	%
Death (0.4%)	0–19	279	0.13
	20–64	944	0.44
	65⁺	901	0.42
	Total	2145	
Hospitalization (1.0%)			
	0–19	751	0.14
	20–64	2414	0.45
	65⁺	2199	0.41
	Total	5363	
Affected population (20%)	536 340		
Physicians (patient ratio 1200:1) : Doctors required			6
Registered Nurse (patient ratio 200:1) Hospitalized patients			38
Enrolled Nurse Asst. (patient ratio 75:1)			
Enrolled Nurses Required			100
Total medical Personnel			**144**

Table 4: Monte Carlo Simulation

Total cases at risk (30%)			
Catergory	Age group	Population	%
Death (0.4%)	0–19	418	0.13
	20–64	1416	0.44
	65⁺	1352	0.42
	Total	3218	
Hospitalization (1.0%)			
	0–19	1126	0.14
	20–64	3620	0.45
	65⁺	3298	0.41
	Total	8045	
Affected population (30%)	804 510		
Physicians (patient ratio 1200:1) Doctors required			9
Registered Nurse (patient ratio 200:1) Registered nurses required			56
Enrolled Nurse Asst. (patient ratio 75:1) Enrolled Nurses Required			150
Total medical Personnel			**216**

500 000 – 800 000 + persons will be infected and approximately 5.3 (000) to 8 (000) persons are expected to be hospitalized while 2.1 (000) to 3.2 (000) would succumb to the disease.

Based on established health-workers to patients ratios (Tables above), the healthcare system will require somewhere between 144 and 216 medical personnel, *ie* doctors, registered nurses and enrolled nurses, to cope with the needs of those who will die or be in need of hospital care. The system will require approximately 100–150 enrolled nurses, 38–56 registered nurses and 6–9 medical doctors.

These estimates, however, are required to cover the health needs of 1.4% of the infected population only. Depending on what proportion of the remaining 98.6% of infected persons and the type and level of care that would be required, it is anticipated that there would be a marginal increase in these numbers.

Conclusion

Given the infrequency of occurrence, the attendant paucity of data and the apparent uncertainty surrounding the behaviour of a pandemic, there is little doubt that many of the assumptions built into this paper may be characterized as subjective and open to criticism or even scepticism. In spite of this limitation, the paper represents a genuine attempt to quantify/measure some of the negative consequences that will flow from a severe influenza pandemic like H5N1.

What is known about the modelling of a pandemic is that the shock to the labour force, *ie*, loss in man hours, due to morbidity and death, will reverberate through out the macro-economy resulting in income and output losses. Obviously, these losses will not be evenly distributed across all sectors. As the study shows, a greater share of the losses will be absorbed by service industries. Every pandemic produces outcomes such as death, hospitalization and an infected population. One of the main challenges is whether the country has the fiscal capacity to procure an adequate supply of vaccine, antiviral and other medical inputs that will be needed to fight the pandemic. In the absence of fiscal resources, the relevant authorities will be compelled to make difficult choices on how to allocate available medical resources.

Apart from the fiscal implications, the available institutional and human resource infrastructure in the public healthcare system will, also, be severely tested as it would need to handle an additional 5 to 8 thousand hospitalized cases within a short space of time plus those among the infected that may be in need of outpatient care.

Any inference about the capacity of the health sector to adequately deal with the expected case load must be judged against the background of some major health indicators that are available. Currently, there are some 24 hospitals and 348 health centres across the country with the highest concentration of facilities in the Kingston Metropolitan Area. In 2007, the bed count in these institutions was approximately 4846 while the bed occupancy rate was recorded at 56.6%. These indicators would suggest that some excess bed capacity exists within the system. The obvious question to ask is whether the healthcare sector will be in a position to cope given the projected inflows of infected persons requiring hospitalization. There is little doubt that the sector will be overwhelmed because it is not in a position to provide the requisite bed spaces to meet expected demand. As a consequence, some major decisions may also have to be made on how to allocate bed spaces.

To mitigate some of the potential bottlenecks and impending dislocations in the provision of healthcare to the sick, the relevant authorities, with a high degree of immediacy, should begin to design and develop a pandemic flu disaster plan. The central focus of the plan must be to marshal private (local) and international resources to effectively improve the readiness of the healthcare system. Preparedness of the state and local entities will probably go a long way in controlling the spread of the flu virus and hence, minimize the potential impact on the macro-economy.

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