ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 01, pp.45280-45294, January, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

ECONOMICS OF THE DIABETIC FOOT:A COST-OF-ILLNESS STUDY IN SAUDI ARABIA

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ARTICLE INFO

Article History:
Received 30th October, 2016
Received in revised form
18th November, 2016
Accepted 05th December, 2016
Published online 31st January, 2017

Key words:

Diabetic foot,
Cost of illness,
Saudi Arabia.

ABSTRACT

Background: Diabetes mellitus (DM) is a chronic disease today's societies encounter. Diabetes symptomatology implies a definitive hormonal background involving insulin production, or its tissue uptake (types 1 and 2 diabetes, respectively); however its exact etiology is still unknown. Diabetes is a disease of complications, e.g., angiopathy, neuropathy; particularly diabetic foot disorders (DFDs) which can be devastating. Amputation, especially following ulceration is a catastrophic endpoint of DFDs. Saudi Arabia suffers a terrifying DM situation (>20% adults), aggravated by high obesity rates and modernized way of living. Above 25% Saudi diabetics develop DFDs, >25% of whom end up with amputation. "Cost of illness" (COI) can be used to estimate the economic burden of DFDs. This work focuses on COI in DFDs in Saudi; identifying risks affecting this cost.

Methodology: Records of adult diabetics with DFDs enrolled with a major insurance agency in Jeddah, KSA were reviewed. Studied data included demographics, intervention options, and reimbursement as a COI measurement during fiscal year (FY) 2015. A quota sample of 60 diabetics was recruited; their risk factors for developed DFDs and COI analyzed.

Results: The median age of participants was 58y (IQR 3y). Male: female 2.53:1; and Saudi: non-Saudi 4:1. Most subjects (43.3%) needed debridement, 35% minor amputation, 15% major amputation, and 6.7% conservative treatment for their DFDs episodes. Age≥55 significantly required more intensive intervention compared to younger age (minor amputation 35% vs. 0%, major amputation 15% vs. 0%, respectively; Fisher's exact 8.567, p=0.011). Age significantly impacted COI [r(df=58) =0.333, p=0.009]. Saudis significantly experienced amputation more frequently than non-Saudis (33.3% vs. 1.7% major amputation, 15.0% vs. 0.0% minor amputation, respectively; Fisher's exact 11.98, p=0.004). They also bear higher COI [t(df 55.6= 4.7, p<0.0001). Mean COI significantly varied by intervention option [F (df 3, 56) =101.3, p<0.0001]. Age could predict change in COI (Exp B = 1.84, 95% 1.2 - 2.74. Although COI varied by type of intervention, the latter could not predict such change in COI.

Conclusion: Age is risk for a worsened DFDs prognosis and higher costs. Saudis are at risk of more costly DFs. The change in COI could be predicted by studied risks. Findings from this work can be used in developing an integrated DFDs database, planning to alleviate DFDs burden and improve the health related quality of life Saudi diabetic patients.

Citation: Turki G. Bafaraj, York F. Zöllner and Hasan A. Alzahrani, 2017. "Economics of the diabetic foot: A cost-of-illness study in Saudi Arabia", *International Journal of Current Research*, 9, (01), 45280-45294.

INTRODUCTION

Diabetes mellitus (DM) is a serious disease that occurs either when the pancreas does not produce enough insulin (type 1 diabetes), or when the body cannot effectively utilize the insulin it produces (type 2 DM) (WHO, 1999). Generally, the majority of diabetic patients are affected by type 2 diabetes. The age predominance of type 2 diabetes traditionally used to occur almost entirely among adult populations; but now it occurs in children too (WHO, 2013a). A sharp demarcation in the global prevalence of the two types thereby barely exists. Diabetes literally represents a major concern for healthcare systems, globally, given the increase in incidence rates among almost all population subsets, disregarding the variability in the demographic or socio-economic status. The global burden of DM is overwhelming. As of 2014, trends suggested the rate of diabetes in the general populations would continue to rise (IDF, 2014). For instance, in 2015, an estimated 415 million people had diabetes worldwide, with type 2 DM making about 90% of the cases. This represents 8.3% of the adult population (Yuankai and Hu, 2014), and with nearly equal rates in both women and men (Vost *et al*., 2012). Importantly, the current epidemiological profile of DM

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probably reflects a universally escalating tendency for risk factors, such as being overweight or obese. Mortality-wise, too, diabetes occupies the 8th position among causes of death due to NCDs (WHO, 2014) e.g., accounting up to 1.5 million deaths in 2012. Higher-than-optimal blood glucose caused an additional 2.2 million deaths by increasing the risks of cardiovascular and other diseases. Forty-three percent of these 3.7 million deaths occur before the age of 70. The toll of diabetes and elevated blood glucose in those under 70 is now higher in low- and middle-income countries than in high-income countries (150 million vs. 0.3 million respectively) (WHO, 2016). Factoring the relatively limited healthcare resources and support these countries might be suffering (Risko *et al*., 2011), an unfavorable health and economic outcome is justified. In Saudi Arabia, the overall epidemiologic picture of diabetes with its risks and consequences is no departure from the global situation. Like most oil-rich countries, leaving behind the physically demanding life of the desert for air-conditioned comfort, servants, and fast food and meat based dishes replacing fiber rich food, Saudi Arabia does struggle with obesity and diabetes (Jalboukh, 2008). The prevalence of DM among adult Saudis has reached 23.7%, a proportion that is one of the highest in the world (Alwakeel *et al*., 2009). The burden of diabetes upon the Saudi society continues to be on the rise. Diabetes negatively impacts the health standard of the Saudi populations and causes a considerable source of drainage in national health funds in terms of the costs associated with treating affected cases and treating the disability and losses incurred due to lost wages and hampered productivity.

Complications, risks, and burden of diabetes are increasingly stressing to medical, social, economic and healthcare planners. The issue is that if not well controlled, diabetes can possibly lead to those complications affecting almost all body systems. Knowledge and awareness about DM, its risk factors, complications, and successful management plan requirements are important aspects for a better control and a better health-related quality of life (HRQOL) (Wild *et al*., 2004). Frequently, by the time people are diagnosed, they have developed severe complications, e.g., microangiopathic processes (as in retinopathy), or macroangiopathic processes [as in ischemic heart disease (IHD)]. Other body organs affected as diabetes and more-than optimum blood glucose progress to complications include central nervous system (e.g., stroke), peripheral nerves (e.g., diabetic neuropathy), kidney (diabetic nephropathy), eye (diabetic retinopathy), and DFDs.
The cost of case negligence and the benefit of prevention and early intervention in diabetes is a notion that is well addressed by the diabetes care providers' community and stakeholders. If not well controlled, diabetes may cause blindness, kidney failure, lower limb amputation and long-term disabilities that impact significantly on the patients' QOL. Although many people living with diabetes are prone to developing foot complications, there are no exact global estimates regarding the particularly lower extremity amputations (Moxey *et al*., 2011). Moreover, diabetes, and its subsequent complications bring about substantial economic losses to patients and their families. These losses involve direct medical costs and loss of work and wages, as seen by the global economic cost of diabetes in 2014 estimated totaling a staggering $612 billion (International Diabetes Federation- IDF, 2013). While the major cost drivers are hospital and outpatient care, a contributing factor is the rise in cost for analogue insulins (derived from human insulin by modifying its structure to change the pharmacokinetic profile), which are increasingly prescribed, despite little evidence that they provide significant advantages over cheaper human insulins (NCD Risk Factor Collaboration, 2007). The facts that certain risks, (e.g., lifestyle, medical, and environmental factors), may precipitate diabetes, especially in the genetically predisposed, and that diabetes itself leads to consequences, some of which, are underlying disease triggers, e.g., hypertension, warrant early intervention to interrupt the circle, and hence control the diabetes problem in the community. Because blood glucose levels can rise to diabetic levels with little or nothing in the way of symptoms, early detection of diabetes would lead to measures to reduce the risk of heart disease, e.g., the use of statins to lower cholesterol, the reduction of blood glucose levels initially by diet and exercise, supplemented with hypoglycemic drugs, as necessary (Waugh, *et al*., 2007). The costs of case finding, e.g., through community screening programs for diabetes are quite reasonable and are balanced in relation to health expenditures as a whole, and facilities and resources available to treat newly diagnosed cases (Engelgau, *et al*., 2000). Although type 1 diabetes cannot be prevented with current knowledge (World Health Organization, 2014), effective approaches are available to prevent type 2 diabetes and to prevent the complications and premature death that can result from all types of diabetes. These include policies and practices across whole populations and within specific settings (school, home, and workplace) that contribute to good health for everyone, regardless of whether they have diabetes, such as exercising regularly, eating healthily, avoiding smoking, and controlling blood pressure and lipids. That the starting point for living well with diabetes is early diagnosis; the longer a person lives with undiagnosed and untreated diabetes, the worse their health outcomes are likely to be. For those who are diagnosed with diabetes, all types, a series of cost-effective interventions can improve their outcomes, such as blood glucose control, through a combination of diet, physical activity and, if necessary, medication; to reduce the risk for complications; and regular screening for organs vulnerable to these complications, including eyes, kidneys, nerves, and feet, to facilitate early treatment.

Especially foot in diabetics is seat for a sequence of insults due to multiple pathological risks involving vascular changes, immune system integrity, neurological impairment, and deranged cell metabolism; all intervene, particularly uncontrolled diabetes. In fact, DFDs are among the most feared complications of DM Clinically, DFDs may present in the form of foot ulceration, infection, neuropathy, deformity, gangrene and/or ischemia. (A combination of any of DFDs symptoms may occur simultaneously, and both feet may be affected). Infected foot ulcers can progress to gangrene and lower limb amputation. Diabetics are 10-20 times more likely to experience amputation than normal population. Recently, a few high-income countries have documented a reduction in amputation rates in people with diabetes (Roglic, 2016). The derangement in the social, psychological, and QOL inflecting diabetics with foot ulceration is truly painful. Cost- wise, the expenditure against caring for diabetics with foot ulceration is five-times greater than that for no-ulcerative peers a year-time after the first diabetic ulcer episode (Driver, *et al*., 2010). All health economies suffer from such costs, e.g., account between 15% up to 40% of the of the world's total healthcare expenditure, (being highest in developing countries) (Boulton, *et al*., 2005). In practice, patients with DF ulcers have a higher demand for health care at all settings, inpatient, emergency or outpatient follow up services. The costs of such services should be endorsed in the cost accounting for any ulcer episodes a diabetic patient may have gone through (Ali, *et al*., 2008). Despite the seriousness of DFDs there is limited research investigating the impact of this group of diabetic health problems on the economic status of the Gulf countries, in general, and Saudi Arabia, in particular. The scanty research on DFDs in Saudi Arabia has been undertaken in hospital setting (Alzahrani, *et al*., 2013). The majority of other hospital-based researcher done elsewhere used quantitative measures of HRQOL, such as, the Nottingham health profile and the Diabetes QOL measure. From the societal perspective, too, it is therefore necessary to consider the economic impacts of DFDs, and identify interventions that can reduce the burden of these health problems. Studying COI is an essential evaluation technique in our attempts to measure and compare the economic burden of DFDs to society (Jo, 2014). Findings from this work help healthcare decision-makers in setting up and prioritize healthcare policies and interventions to improve diabetes outcomes in the community.

MATERIALS AND METHODS

Study Setting

This study was conducted in Jeddah; K.S.A. Jeddah is a coastal city on the western bank of the Red sea in the western region of the KSA. The city has around 3.4 million populations, representing almost 13% of the total population of the kingdom (which is estimated at 27,136,977: 18,707,576 Saudi nationals and 8,429,401 non-nationals, as in 2010 census, with a national growth rate around 1.49%),(Saudi Arabia Population Clock). Over the last few decades, Jeddah has grown progressively until it became second largestcity in the country and center for money and business, and a major port for exporting non-oil related goods, as well as importing domestic needs in the country. Jeddah is also considered the touristic capital of Saudi Arabia especially that it is the main gateway for millions of pilgrimages and visitors from all over the world to the Islamic holy cities Mecca and Medina. The commercial and diversified nature of Jeddah gives room for private health care business for a shared responsibility of community health in a rivalry-motivated environment, which can be positively reflected upon the clienteles and the providers. Further, business organizations in Jeddah compete in retaining good human resources base through securing health insurance for staff and their families [Council of Cooperative health Insurance (CCHI), 2016]. The critical nature of the disease under study, DM, necessitated resorting to a reliable source of health and economic information in order to assure highest degree of validity and representativeness of the study results to the general population. Our systematic search in the health insurance marketplace in Jeddah led to a short list of reputed health insurance rivals. Bupa Arabia (BA) (http://www. bupa.com.sa), a division of the international Bupa group, is one of the largest health insurance corporations working in Saudi Arabia, since 1997. Official information shows that over 3 million members are enrolled with this company up to date.

Study Design

As per the study plan, diabetic patients' information congruent with the study objectives would be outreached. Accordingly, BA had been selected and to whom the research idea was conveyed, aiming to gain access to patient information which would serve the study goal. A medical liaison from BA was assigned to cooperate in providing the dataset permitted to us by the company's authority. Patient records with type 2 diabetes mellitus since 2007 or earlier have been identified. Out of these records, patients who show history of DFDs and were reimbursed for any DFDs care during 2015were reviewed. Authorization to access patient data with specific restrictions and fulfilling a series of confidentiality requirements on the part of patients and BA had to be acknowledged and applied.

The study participants

According to the study design, a subject is labeled as "type 2 diabetes mellitus" if she or he met the International Classification-9- Coding Manual (ICD-9-CM) criteria for type 2 DM diagnosis(ICD-9-CM, 2011), ICD-9: 250.00 refers to diabetes mellitus without mention of complication. As per ICD-9, any disease is given a 5-digit number, the last pair of digits of which is left for complication coding. For instance, 250.70 is the code given to type 2 DM with peripheral circulatory disorders not stated as uncontrolled and 250.72 is the code given to type 2 DM with peripheral circulatory disorders stated uncontrolled, and so forth. (ICD-9-CM 250.80 is a billable medical code that can be used to indicate a diagnosis on a reimbursement claim. (However, 250.80 should only be used for claims with a date of service on or before September 30, 2015; and for claims with a date of service on or after October 1, 2015, ICD-10-CM code equivalent can be used).(See Appendix-B for DM ICD-9 coding). According to ICD-9-CM, DFDs are coded as 250.00which implies either diabetes with other specified manifestations, type II or unspecified type, diabetes not stated as uncontrolled plus codes for systemic diseases compatible with the DFDs. [Diabetic foot disorder include, ulcer of heel and mid foot include carbuncle and furuncle of foot, heel, toe (680.7), cellulitis and abscess of toe (681.1), cellulitis or abscess of foot (707.14), chronic osteomyelitis of ankle and foot (730.17), unspecified infection of bone of ankle and foot (730.97), atherosclerosis of the extremities with ulceration (440.23)]. (See Appendix B).The insureruses industry standard codes developed by "Clinical Coding and Schedule Development Group" (CCSD) (CCSD, http://www.ccsd. org.uk/), which contain codes for produces guidance to enable accurate coding of clinical activity in independent healthcare. Each ICD-9 diagnosis code of participants and its CCSD equivalent used by BA were matched for accurate admission to the study.(See Appendix C). Cost information was based on the reimbursement schedules provided by BA and according to the billing and reimbursement system in action the time of the study. The insureruses a billing system which utilizes electronic submission of invoices for accurate reimbursement.[The system is derived from the original International Classification of health Interventions-ICHI-coding system(ICD-9-CM, 2011)], (Reimbursement policy information is displayed in Appendix C).

Inclusion criteria

Patients included in the study if they fulfilled ICD-9-CM diagnosis of type 2 DM, has been enrolled with BA and developed and received medical and / or surgical care for any DFDs which have been reimbursed for during 2015.As such, only direct costs for the DFD incidents covered from 2015 budget was analyzed. Patients should also be adults who stay in Jeddah, as the place of permanent residence the time of the study. Otherwise, no patient would be excluded from the study because of sex, marital status, socioeconomic status or underlying health condition. Also all types of insurance policies were allowed, whether part of a group insurance policy by the employer or individual and private insurance policies.

Sampling Technique and Sample Size

A sample frame containing enrollees diagnosed with diabetes and who had developed any DFD episode which was reimbursed in 2015 were identified. A quota sample of 60 patients had been permitted by BA to be included in the study.

Data Collection

A data collection form was predesigned by this researcher in order to administer the required patient information. (See in Appendix A; spreadsheet). The form includes five major fields, case and disease coding, demographic, clinical and procedural, as well as direct cost data fields. At the beginning of this project, there was a sincere desire to gather a full scope of demographic and clinical information to be used as potential risks of a hypothesized influenceon the development of DFDs in the study participants. However, restrictions imposed on information pertinent with the patients' socioeconomic status, education, underlying health status and comorbidities, and also health care costs during enrollment other than those for DFDs reimbursed in 2015 were not given. The rationale by BA was not to jeopardize patients' confidentiality and not to breach the company's billing and financial secrecy policy.

The Study Variables

Demographic variables include age in years [an interval ratio scale (IRS)variable], sex (male or female), and nationality (Saudi or non-Saudi), both of which are dichotomous. Clinical variables include types of diabetic foot complication, as well as the specific medical and/or surgical intervention applied to each condition. Intervention data consist of five categories: a) conservative only, b) debridement, c) minor amputation, and d) major amputation. (Appendix A). Eventually, two sets of risk variables are studied, demographic criteria and intervention type. The terms "risk factor", "risk", "input", "correlate" "dependent variable", all can be used exchangeable for these risk variables above. Cost data (expressed here as an IRS variable) indicate cost of DFDs illness per diabetic foot disorder incident each participant had encountered and led to one of the treatment procedures described above. The COI accounting was based on the following financial information:

a) Subtotal direct medical costs, such as doctor's fee, outpatient visits, medicines, devices, hospital stay, and surgery.
b) Subtotal non-medical costs, such as transportation, communications, extra accommodation or room accommodation and the likes.
c) COI = subtotal direct medical/surgical costs + subtotal direct medical/surgical costs, less deducible and copayment, (i.e., deductibles and copayment are not included in COI); all in Saudi Riyal (approximate transfer rate: $0.267).

NB. Indirect costs, such as employee time, rehabilitation or home care costs all were not included in the study, since they are not covered by the insurance plan. Also, extra medical charges paid at the patient's expense or outside the insurance plan were not be included. Eventually, two outcome (dependent) variables would be deployed for this study, type of intervention (an intermediary outcome), and COI as the final outcome of interest.

Statistical Analysis

First, obtained data were entered into a Microsoft system with adequate back up. Statistical analysis included both descriptive statics and analytical statistics. For instance, IRS variables, such as COI and age would be described in terms of the mean ± standard deviation (SD) or the median ± interquartile range (IQR), where appropriate. [Selecting either the mean or the median as a most appropriate measure of central tendency depends on assumptions relevant to parametric techniques (PMTs), important of which are normality and sample size]. Categorical variables, such as sex and nationality would be described in count and percentage. As far as inferential statistics, the influence of the study correlates, e.g., the difference in the level of COI among the study's gender groups could be measured using student- test, or Mann Whitney-*U* test, where appropriate(i.e., based on normality distribution of COI variable, as well as other PMT assumptions, as applicable). Likewise, the influence of the type of intervention upon COI may be measured using one-way analysis of variance (ANOVA) test or its nonparametric alternative Kruskal Wallis test, where appropriate (based on PMT assumptions fulfillment). Importantly, normality of the study's interval scale data could be assessed using one of the normality measuring techniques, such as the one-ample Kolmogorov Smirnov (K-S) test. In this research we tended as a rule in analyzing the impact of the study correlates on the study outcomes to run both PMT and non-PMTs for the same relationship. Should there was a difference in the significance result between the two approaches the non-PMT would be prioritized (not to violate the normality assumption for PMT calculation). If the two approaches yielded significant results, PMT could be adopted and safely discussed. [This strategy, for instance applies to t-test vs. Mann-Whitney-*U* test, ANOVA vs. Kruskal Wallis test, linear regression vs. logistic regression analyses, and Pearson correlation vs. Spearman rho techniques (see later)].Also, the association between any of the demographic categorical variables such as nationality and the type of DFD intervention could be assessed using chi square test of independence, and either Pearson chi-square or Fisher's exact test for significance, where appropriate. (The latter is used if ≥25% of cells in cross-tabulation contains less than 5 expected count).In case we wished to measure the relationship between age and COI (both are IRS continuous variables), correlation analysis could be calculated.(Both Pearson's correlation and Spearman rho would be calculated, according to the PMT/non-PMT testing policy above, and either of them is selected for display, where appropriate). Finally, a model to predict the probability of the change in the dependent variable "COI" as a result of a unit change in each predictor would be constructed. (Both multivariate linear regression and logistic regression analysis would be tried, as per the PMT/non-PMT policy). In case COI was skewed, the differences in the levels of COI among sex, nationality, and intervention groups would be attempted both utilizing PMT and non-PMTs alternatives, as above. Also COI may be transformed into a binary variable, namely SR<35,000and ≥SR35,000 to calculate the logistic regression test of interest. The statistical analysis plan would be set forth so that the influence of the independent variables may be tested both upon the type of intervention and COI. Intervention, as an intermediary variable may be tested against COI as the final outcome variable. Eventually, two phases of statistical analyses would be conducted; each encompasses a set of tests. In the first phase, we will measure the effect of selected study determinants upon the type of intervention. In the second phase, the effect of selected determinants as well as the type of intervention upon COI will be measured. The study findings would be displayed summarized as tables and graph charts, such as histograms, bar graphs or pie charts, as appropriate. Besides, a brief narrative comment opposite each finding would be added. The Statistical package for social sciences version 18 (SPSS Inc., Chicago, IL, USA) was used in the analysis. Our tolerable alpha error is 0.05 and results with p-value <0.05 would be considered significant. Also the 95% confidence interval (CI) of the odds ratio (OR) may be used to assess the significance of the strength of association between risks and dependent variables measured by OR as in chi square or regression analysis tests.

Ethical Considerations

Early in this work, it was quite expected to face difficulty in gaining access to patient records, especially in a disease such as DM. This disease condition implies many personal and moral concerns to individual patients, and thereby it was well-understood to abide by confidentiality standards applicable to the selected data source, such as the selected insurance agency. Especially the latter holds high accountability and liability for personal information confidentiality. It was also understood that only anonymous patient data may be accessed and utmost insured information confidentiality ascertained. On our part, we declared and acknowledged before the insurer that the obtained information would remain anonymous by de-personalizing names and places in the transcriptions and ascertained that only grouped information would be disclosed to the public at scientific and research settings.

The Role of the Researcher

The idea of this research arose from the desire of this researcher to apply some valuable public health and health economics expertise acquired while in direct contact with renowned public health sources in Germany and Europe to the quest of healthcare of Saudi Arabia. Diabetes in particular was selected to study because of the tremendous impact upon the Saudi Arabia, homeland for this investigator. During medical training in Saudi Arabia before joining the master program of public health in Hamburg University, this researcher realized the enormous burden of diabetes, especially associated with underlying co morbidities, such as obesity and unhealthy nutritional habits widespread in today's Saudi community. Thereby, there was a wish to address diabetes from the angle of one of its severest complications, which is DFDs. Thereby, this researcher was adamant to tackle all possible sources of DM and DFDs data and could conclude this research plan with one of the largest and most reputed insurance agencies in the country. This researcher has developed the study's goal and objectives plan, bearing in mind highlighting objectives that are reproducible and measurable, using the available set of data. Handled by this researcher, too, but not limited to, were data entry, coding, preliminary handling, and conducting thorough literature review from best evidence resources relevant to the topic, interpretation and discussion of the research findings, timeline setting (see appendix F), write-up formatting, referencing, appendix arrangement, and abstract transcription. Help was sought with respect to the statistical analysis which needed more specialized experience, particularly deciding about most appropriate statistical techniques.

RESULTS

Descriptive Statistics Results

Table 1. Descriptive Criteria of Study Group: Age, Sex, Nationality, COI (n = 60)

Variable			
Age (year)			
Mean	57.28±2.65		
Median	58.00		
Mode	60.00		
Range	13 (Min 47; Max 60)		
25th percentile	56.00		
75th Percentile	59.00		
Interquartile Range (IQR)	3.00		
COI (SR)			
Mean	33622.08±26067.073		
Median	27817.50		
Mode	9859		
Range	131527 (Min 9859; Max 141386)		
25th percentile	14582.75		
75th Percentile	38916.00		
Interquartile Range (IQR)	24333.25		
		n	%
Sex			
Male		43	71.7
Female		17	28.3
Nationality			
Saudi		48	80.00
Non-Saudi		12	20.00

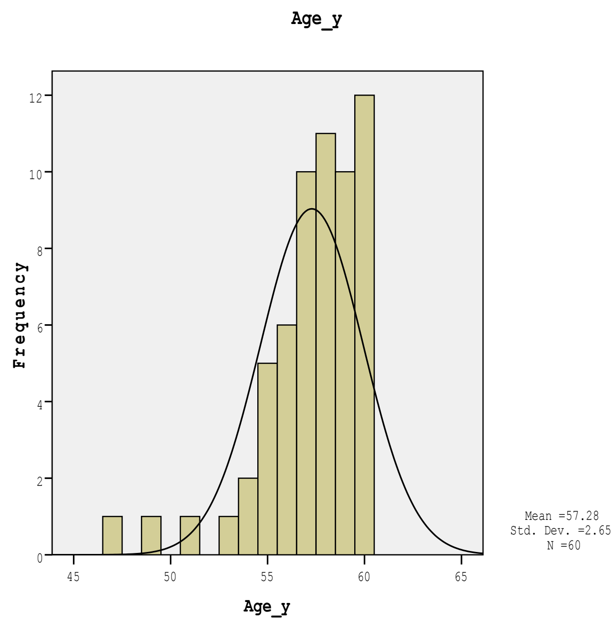

Figure 1a. Histogram: Age Distribution Pattern of the Study Group

Figure 1a shows that age apparently looks rather left-sided skewed; however, K-S test suggested a normal distribution (Z=1.384, p=0.053). In contrast, COI was not normally distributed (Z=1.47, p=0.027), (Figure 1b). (See Appendix D for K-S output).

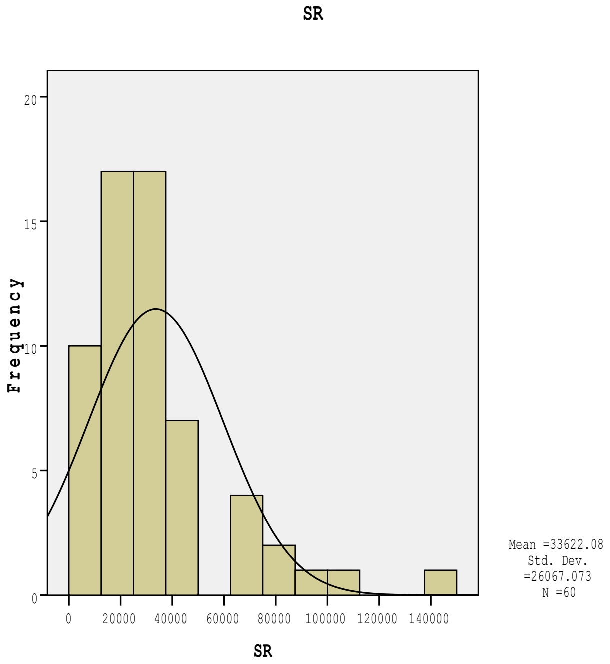

Figure 1b. Histogram: Cost of Illness (COI) Distribution Pattern of the Study Group

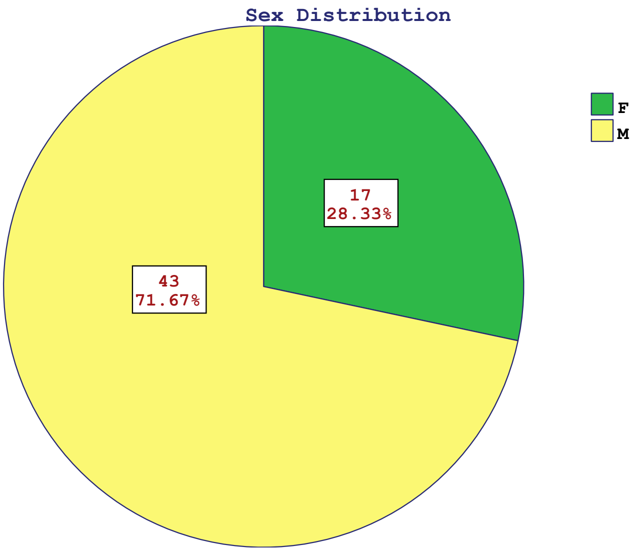

Figure 2. Sex Distribution Pattern of the Study Group

Table 2. Distribution of the Study Group by Type of DFD Intervention (n = 60)

Intervention	N	%
Conservative treatment only	4	6.70
Debridement	26	43.3
Minor amputation	21	35.00
Major amputation	9	15.00
Total	60	100.00

As in Table 2, the majority (43.3%, n=26) of the study group had debridement as the first line of treatment for their DFD episode. Second to debridement was minor amputation in the frequency of 21 (35%) incidents. Major amputations affected 15.0% (n=9) of the study population. Least occurring was conservative treatment alone (6.7%, n=4 cases). (See also Figure 3).

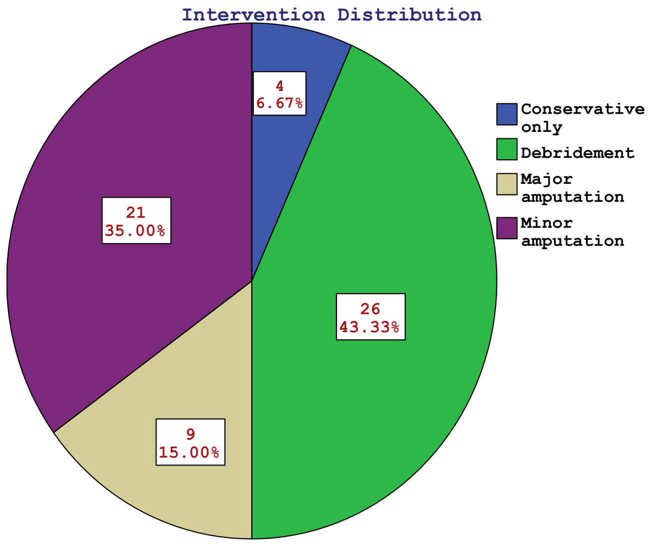

Figure 3. Intervention Options Distribution Pattern of the Study Group

Analytical Statistics Results

Phase 1: Influence of the Study Determinants upon Type of Intervention

The relationship between age and type of intervention (Table 3, Figure 4)

As in Table 3, the effect of age (binary: <55y and ≥55y) was examined as a risk factor for the type of intervention. a chi-square technique calculation shows that patients with DFDs who were 55-years old or higher are significantly at greater risk of requiring lower extremity amputation whether minor (35.0%) or major (15%) ones (Table 3). (See also Figure 4 for comparative distribution). Among the non-amputation categories, diabetics ≥55 were also more likely to need debridement (36.7%) compared to the <55y counterparts (6.7%); however both age group did not differ in the need for frequency of conservative treatment alone (Fisher's exact 8.567, p=0.011).

The relationship between sex and type of intervention (Table 4)

In another cross tabulation to evaluate the influence of sex upon the type of intervention, no significant effect has been found (Fisher's exact 0.427, p=0.968), (Table 4).

The relationship between nationality and type of intervention (Table 5, Figure 5)

Evaluating the relationship between nationality and type of intervention among our DFDs group, chi-square testing showed that the prevalence of amputation incidents (both major and minor) among Saudi diabetics significantly exceeds that among the non-Saudi counterparts [33.3% vs. 1.7% major amputation, and 15.0% vs. 0.0% minor amputation, respectively) (Table 5). The same trend is observed in regard to debridement and conservative treatment [25.0% vs. 11.8%, and 5.0% vs. 1.7%, respectively], (Fisher's exact 11.98, p=0.004) (Table 5). (Also see Figure 5 for a comparative distribution).

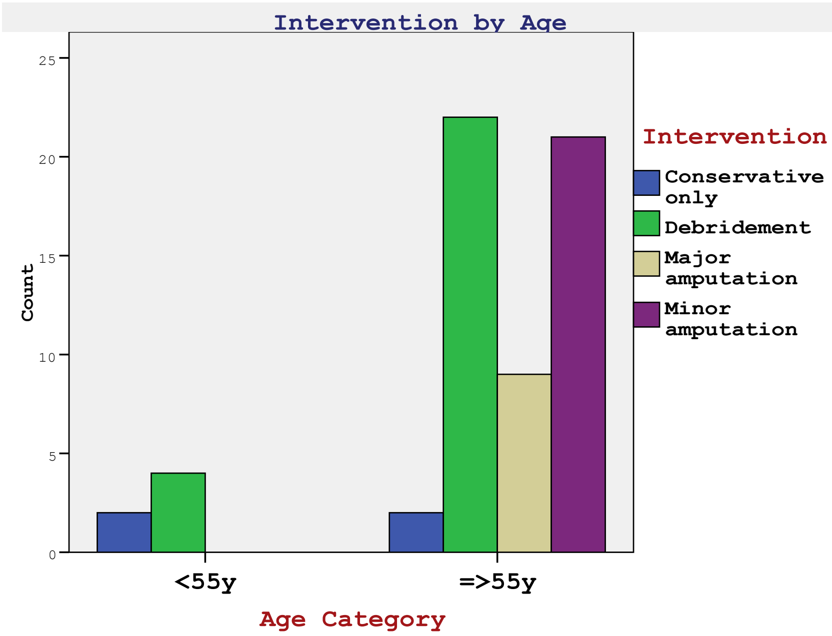

Figure 4. Distribution of the study DFDs Intervention Groups by Age Category

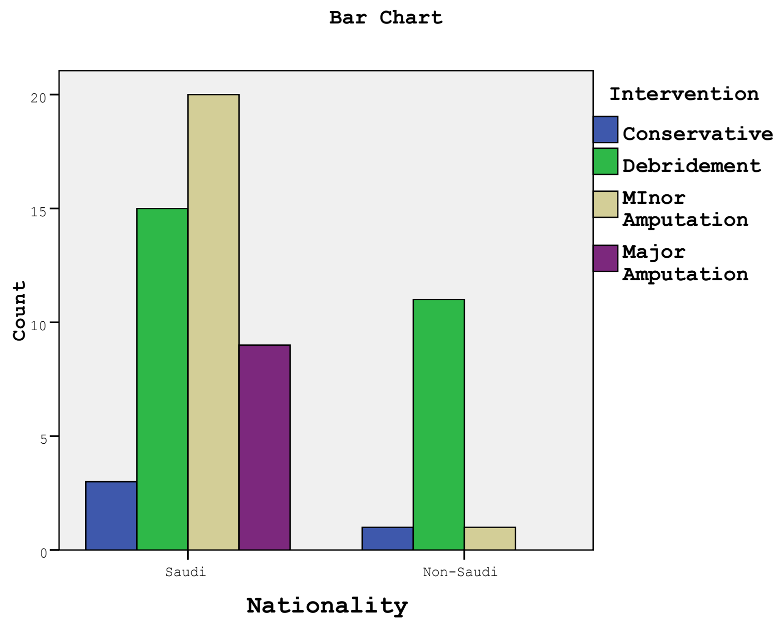

Figure 5. Distribution of the study DFDs Intervention Groups by Nationality: Saudi vs. Non-Saudi

Table 3. Influence of Age upon the Prevalence of Specific DFDs Interventions: Cross tabulation

Age category		Intervention				Total	Test statistic (p-value) (2-tailed)
	n	Conservative only	Debridement	Minor amputation	Major amputation		
<55y	Count	2 (3.3%)	4 (6.7%)	0 (0.0%)	0 (0.0%)	6 (10.0%)	
	Expected	0.4	2.6	2.1	0.9	6.0	Fisher's
≥55y	Count	2 (3.3%)	22 (36.7%)	21 (35.0%)	9 (15.0%)	54 (90.0%)	exact =8.567
	Expected	3.6	23.4	18.9	8.1	54.0	(p=0.011)
Total		4 (6.7%)	26 (43.3%)	21 (35.0%)	9 (15.0%)	9 (15.0%)	

Table 4. Influence of Sex upon the Prevalence of Specific DFDs Interventions:Cross-tabulation

Sex category		Intervention				Total	Test statistic (p-value) (2-tailed)
	n	Conservative only	Debridement	Minor amputation	Major amputation		
Male	Count	3 (5.0%)	19 (31.7%)	15 (25.0%)	6 (10.0%)	42 (71.7%)	
	Expected	2.9	18.6	15.1	6.5	43	Fisher's
Female	Count	1 (1.7%)	7 (5.7%)	6 (10.0%)	3 (5.0%)	17 (28.3%)	exact = 0.427
	Expected	1.1	7.4	6.0	2.6	17.0	(p=0.968)
Total		4 (6.7%)	26 (43.3%)	21 (35.00%)	9 (15.9%)	9 (15.9%)	

Table 5. Influence of Nationality upon the Prevalence of Specific DFDs Interventions: Cross tabulation

Nationality	Intervention					Total	Test statistic (p-value) (2-tailed)
	n	Conservative only	Debridement	Minor amputation	Major amputation		
Saudi	Count	3 (5.0%)	15 (25.0%)	9 (15.0%)	20 (33.3%)	47 (78.3%)	
	Expected	3.1	20.4	7.1	16.5	47.0	Fisher's
Non-Saudi	Count	1 (1.7.0%)	11 18.3(%)	0 (0.0%)	1 (1.7%)	13 (21.7%)	exact = 11.98
	Expected	0.9	5.6	2.0	4.6	13.0	(p=0.004)
Total		4 (6.7%)	31 (43.3%)	9 (15.0%)	21 (35.0%)	21 (35.0%)	

Table 6. The Relationship between Age and COI

	Correlation	COI (SR)
Age (y)	Pearson Correlation	0.333
	p-value	0.009
	n	60

Table 7. The Relationship between Sex and COI: Two Independent Samples t-Test

	Levene's test (equality of Variances			t-test for Equality of Means					95% CI of the difference	
COI (SR)		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	SE Diff.	Lower	Upper
	Equal variances assumed	0.122	0.728	0.075	58	0.941	562.78*	7531.83	-14513.8	15639.4
	Equal variances not assumed			0.082	36.53	.935	562.78	6838.78	-13299.9	14425.5

* Mean COI male= 33462.63(SD 27696.2). Mean COI female = 34028.4 (SD 22176.7)

Table 8. The Relationship between Nationality and COI:Two Independent Samples t-Test

	Levene's test (equality of Variances			t-test for Equality of Means					95% CI of the difference	
COI		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	SE Diff.	Lower	Upper
	Equal variances assumed	8.23	0.006	2.62	58	0.011	20383.2	7791.8	4786.1	35980.3
	Equal variances not assumed			4.7	55.6	<0.0001	20383.2	4324.3	11719.1	29047.4

* Mean COI Saudi= SR38038.5 (SD 27781.7). Mean COI non-Saudi = SR17,655.2 (SD 5441.6)

Table 9a. Difference in the Mean COI of the Four Intervention Group Options among the Study Population: ANOVA Test

Intervention Category	N	Mean COI (SR)	SD	Std. error	95% CI of the difference	
					Lower	Upper
Conservative Only	4	10278.75	480.68	240.34	9513.88	11043.62
Debridement	26	17276.00	5396.72	1058.38	15096.22	19455.78
Minor amputation	21	35892.33	6109.51	1333.20	33111.32	38673.35
Major amputation	9	85921.67	24399.18	8133.06	67166.79	104676.54
Total	60	33622.08	26067.07	3365.25	26888.24	40355.92

Table 9. b ANOVA Analysis: Mean Difference among DFDs Groups

	Sum of Squares	df	Mean square	F	p-value
Between Groups	33852152781.167	3	11284050927.056		
Within Groups	6237893043.417	56	111390947.204	101.301	<0.0001
Total	40090045824.583	59			

Table 10. Predictability of Independent Variables Age and Sex on the Chnge in COI: Logistc Rgerssion Analysis

Independent variable	B	S.E.	Wald	df	Sig.	Exp (B)	95% CI for EXP (B)	
							Lower	Upper
Sex(1)	– 0.141	0.667	0.045	1	0.832	0.868	0.235	3.209
Age	0.596	0.210	8.003	1	0.005	1.814	1.201	2.740
Constant	– 35.221	12.262	8.250	1	0.004	0.000		

Phase 2: Influence of the Study Determinants upon COI

The relationship between age and COI: correlation analysis. (Table 6)

Correlations Analysis

As in Table 6, there is a week (33.33%) but highly significantly correlation between age and COI [r(df=58) =0.333, p=0.009]. [In a Spearman's correlation test rho calculation, correlation was as higher as moderate (Spearman's rho=0.467, p<0.0001]. (Appendix D).

The Relationship between sex and COI: student t-test. (Tables 7)

In Table 7 above, the mean COI did not significantly differ between the two gender groups (Mean COI male = SR33462.63± 27696.2, mean COI female = SR34025.41 ±22176.7) (Table 8 footnote) (difference = SR562.78) (Table 8) [t(df = 0.075, p=0.941).

The relationship between nationality and COI: student t-test. (Tables 8)

In Table 8 above, the mean COI significantly differed between Saudi and non-Saudi groups. Saudis incur average SR38038.5 (SD 27781.7) while non-Saudis incur average SR17,655.2 (SD 5441.6) in COI (Table 8, footnote). The difference in the mean COI between the two nationalities (SR20383.2) (Table 8) was statistically significant [t (df 55.6) = 4.7, p<0.0001). (Mann-Whitney-*U* test also gave significant difference). (Appendix D).

The relationship between type of intervention and COI: one-way ANOVA. (Tables 9a, 9b)

As in Table 9b above, the mean COI increases gradually by the intensiveness of the intervention procedure: The mean ± SD COI (SR) for the procedures are as follows: conservative treatment only = 10278.75± 480.68; debridement = 17276.00± 5396.72; minor amputation = 35892.33± 6109.51; and major amputation = 85921.67± 24399.18. The difference in these means was statistically significant [F(df 3, 56)=101.301, p<0.0001] (Table8b). A post-hoc test [least square difference (LSD)] was also conducted to measure the "within-groups" difference in COI. Most comparisons were significantly different. (See Appendix D). (Kruskal Wallis test also gave significant difference). (Appendix D).

Predicting the change in COI to changes in selected outputs (Table 10)

Near the end of the analysis, a multiple logistic regression model was fitted to measure whether the selected independent variables could predict change in COI due to a unit change in each independent variable. The COI was first modified as <SR35,000 and ≥SR35,000 as the binary independent varlable for the model. In Table 9, the regression coefficint (B) for age is positive 0.596. Exponent B for age (column 7, Table 9) is the odds ratio (OR) (which is anti-log of B) of the impact of age upon COI. It indicates that a higher COI is 1.814 times significantly more likely to be associated with higher age [ExpB=1.81, 95% confidence interval (CI) 1.201 – 2.74]. Interpreting output Table 9, too, the fitted regression model for the included variables would be constucted in the for of the following formula:

$$[P/1 - P] \text{ Change in COI} = \frac{e^{-35.221 + 0.596 (\text{Age}) - 0.141 (\text{Female})}}{1+e^{-35.221 + 0.596 (\text{Age}) - 0.141 (\text{Female})}}$$

DISCUSSION

The cornerstone of mitigating diabetes complications and alleviate its burden is to control blood glucose level and guard a higher than optimum glucose levels by all means and under all circumstances. The longer the normalization of PG levels the farther postponement of developing diabetic macrovasculopathy, neuropathy and impaired immune response to infectious agents (Hammes, 2003; O'Gara, *et al.*, 2013). These disorders endanger foot tissue health and integrity and if not controlled DFDs of variable severity and implications are precipitated (Macleod *et al.*, 1996; Tashkandi, *et al.*, 2011). Although many diabetics are at risk of developing DFDs the exact estimate of DFDs and hence exact economic burden and COI attributed to them are lacking, globally (Moxey *et al.*, 2011), and locally (Alzahrani *et al.*, 2013).

Interpreting Demographic Findings in Relation to DFDs Intervention Outcome

We first found that both age and Saudi nationality were risk for a severer DFD prognosis. On the other hand, sex had no influence upon our study outcomes. In Saudi Arabia, too, Alrubean *et al.* (2015) found that age, male sex, and diabetes duration were risk factors for worse diabetes diagnoses. Alrubean and collaborates' work was based on reviewing the Saudi National Diabetes Registry (SNDR), whereas it was claimed that only a total 2,071 DFD cases were registered with SNDR, and 32.20% of those who sustained worst diagnoses (ulcer and gangrene) had major amputation. The amputation frequency in Alrubean *et al.*, also closely compares to ours (35.0%). In our study we would be concerned about such high amputation rate in a population who is fully covered and supposedly having access to good medical care. Alrubean and colleagues' finding that 2071 subjects with DFDs all through 2000 till 2012, raises another concern about DFDs situation in Saudi Arabia. Assuming the least estimate of 3.3% DFDs in KSA, as in Alrubean *et al.* this should account to not less than 100,000 cases [considering 3.4 million with diabetes in KSA (International Diabetes Federation, 2015) and that 90% of them are type 2 (International Diabetes Federation, 2014)]. The large difference in DFDs rates between the two reports warrants further inquiry about the true reason for under-reporting diabetes disorders and the reluctance to administer DFDs incidents in the SNDR. While between 15% and 35% of our DFD patients were victimized with amputation, this rate also conforms to what has been speculated elsewhere that severer DFDs not timely and properly managed might end up with amputation in 15%-27% of cases (Alzahrani *et al.*, 2013). The issue is that Saudi Arabia envisions a progressive medical, strategic, and administrative advance in health services (Almalki *et al.*, 2011; Walston *et al.*, 2008; World Health Organization-WHO, 2013) including diabetes care capabilities. Therefore, the discouraging DFDs outcome reported in our study perhaps fails our expectation of a better outcome in a community that is well-served and driven by market economy such as Jeddah. Many factors could be incriminated in our attempt to understand the mismatch between this unfavorable health outcome and the reasonably good financial and health system inputs.

Little studies addressed the prevalence and risks of DFDs among Saudi Arabian citizens (Alrubean *et al*., 2015; Alzahrai *et al*., 2013) in agreement with our instinct with this regard. Instead, the prevalence of diabetes itself in Saudis compared with other nations has been documented by many other studies (Afifi *et al*., Al-Nozha *et al*., 2015; Alrubean *et al*., 2015; Al-Wakeel *et al*., 2009; IDF, 2015). Diabetes in Saudi Arabia reached 23.7% (Alwakeel *et al*., 2009) a proportion that is one of the highest not only in MENA zone but in the world (Alwakeel *et al*., 2009), and that is prone to grow to astronomical numbers, e.g., 283% by 2030, (International Diabetes Federation, 2015) if the Saudi diet style and physical inactivity persist and no radical intervention plan has been enforced. In diabetes, early detection of clinical and pathological risks for DFDs, namely vacuities, neuropathy and skin infection of the foot, is critical (American Diabetes Association, 2015; Canadian Diabetes Association, 20013; Griffth *et al*., 2010; Hammes, 2003; Khan *et al*., 2010; Zhang, *et al*., 2010). These pathologies frequently overlap in the same DFD episode and progress to resistant foot ulcer and then amputation (Al-Rubeaan *et al*., 2015; Boulton *et al*., 2008). A radical strategy to handle diabetes problem in Saudi should rest on prevention, early detection of prediabetes and uncontrolled diabetes cases and continuous monitoring of A1C in known diabetics (Afifi *et al*., 2015). Especially the high risk, diabetics should be given specific consideration at family medicine and primary healthcare setting. There should be also an emphasisona combined screening strategy for high risk groups, including the obese, less served communities, and the low socioeconomic class (Ackermann *et al*., 2011). Even the high socioeconomic class should be considered in risk detection and prevention of DM. The two socioeconomic classes have reasons to an exaggerated diabetes opportunity. The unfortunates lack access health care both in quantity and quality (Selvin *et al*., 2010). The less educated may not have the enthusiasm for health education and realizing its role in preventing chronic diseases that impact health, survivability and QOL (Alzahrani *et al*. 2013; American Diabetes Association- ADA, 2015; Griffth *et al*., 2011; Khan *et al*., 2010; Moxey *et al*., 2011; Tashkandi *et al*., 2011; Wild *et al*., 2004). The rich are often intimidated by easy life and often unhealthy diet (Jalboukh, 2008), as well as technologies which bring the plenty oflife utilities at their fingertips and persuade physical inactivity.

Discussing COI Findings

I literature, the cost per person with diabetes in Saudi Arabia mounts up to $1,145.3 (IDF, 2015). This implies that the Saudi society spends over $15 billion on DM [$1145.3 * 3.4 million estimated diabetics, (IDF, 2015)], while the outcome, e.g., 15%-35% amputation as in this study and 27.9% - 44% individuals with undiagnosed DM (Afifi *et al*., 2015; Al-Nozha *et al*., 2015) does not live up to what was expected from such investment. The median COI for DFDs care in our study was SR27, 817.50 ($7,418 equivalent) (IQR= SR 24,333.25); the mean COI was SR33, 622.08 ± 26,067.073 (= $8965.9 ± 6951.2); and a range of SR131,527 (minimum SR9859 and maximum SR141,386). Data from a recent sample-based study on the cost of DFD illnesses in Saudi Arabia by Alzahrani, *et al*. (2013) showed that the median COI totaled SR12, 819.5. The median COI of Alzahrani *et al*., is less than half that in our work. Both Alzahrani *et al*. and our study share a common setting and some clinical criteria. For instance, the two studies were conducted on Jeddah diabetic patients, and also the broad clinical intervention categories were almost identical (conservative treatment alone, debridement, minor amputation, major amputation). Other studies elsewhere on DFDs also tended to use the same clinical intervention classification (Boulton *et al*., 2005). According to Alzahrani *et al*., study design, recruitment was limited to DFD patients upon a single hospital admission to receive inpatient care for their stressing DFD condition. Further, the length of hospital stay only averaged 9 days (compared to similar studies with longer hospital stay, Benotmane *et al*., 2008. In practice, however, patients with DFDs tend to require more frequent emergency department visits and outpatient appointments, and probably other follow up procedures in-between visits, Boulton *et al*., 2005). Therefore, a larger-scale costing studies for DFDs not only includedthe immediate DFDs episode costs but other costs, such as Benotmane *et al*. (2008) and Boulton *et al*. (2005) are often be required. Needless to say, indirect cost items may also be calculated. However the estimation of these costs is not always possible, especially in the presence of obstacles that limit the allocation of resources for a comprehensive COI study. The frequency of debridement intervention in Alzahrani *et al*. and us was highest among all DFDs procedures (48.8% vs. 43.3%) (See Appendix D for comparative tables between the two studies developed by this researcher). Findings from western DFDs costing research report variable median costs for DFDs care. The trend was that lower limb amputations usually cost higher than non-surgical care. The median cost in Australia for lower extremity amputation was A$12,485, (range 6,037-24,415) (Davis, *et al*. 2006), i.e., compared to $9,288 – $20,569 median COI for minor amputation and major amputation, respectively in our study) (see Appendix D for detailed comparative COI Table). Highest among all, $32,129 is the median cost in admission for ischemic limb ambulation in U.S.A. (Peacock, *et al*. 2008). The differences in study designs, procedures, length of hospital stay, as well as the variability in health benefits and billing systems alongside with the variability in each country's economics and living expenses all can cause variability in COI of DFDs care. As in the type of intervention analyses, age and nationality were risks for incremental COI. Comparable results have been reported by other COI in DFDs studies (Afifi, *et al*., 2015; Alrubean, *et al*., 2015). Typically, diabetes complications develop after many years (10–20), but may be the first symptom in those who have otherwise not received a diagnosis before that time. As such, older diabetics are at greater risk of suffering a complicated disease(Abulfotouh, *et al*., 2011; Alrubean, *et al*., 2015; Reiber, *et al*., 1998).

Discussing the Regression Analysis

Multiple linear regression analyses were first attepted and no significant predictibilities by the entered predictots for the change in COI were found. Alternatively, logistic regression would be conducted; in which case COI would be transformed into the binary dependent variable for conducting the logistic regression technique. First a cutoff point at around the median COI was selected (<SR60,000 and ≥60,000) but the model could not preict the change in the COI. When the cutoff point was decreased gradually until 35,000, significant effect was obtained. Although type of DFDs care did impact the level of COI (ANOVA analysis), its effect as a dummy variable on the change in COI was not significantly receognized wnen first

entered to the logistic model, thereby they were removed. Fnally, age only could predictor for COI change. For instance, if a 60 year old (male) diabetic dveleoped DFDs (any type), the probability for a change in COI because of age, (sex is not significant), will be:

$$[P/1 - P] \text{ Change in COI} = \frac{e^{-35.221 + 0.596\,(60) - 0.141\,(\text{Zero})}}{1 + e^{-35.221 + 0.596\,(60) - 0.141\,(\text{Zero})}} = \frac{1.71}{2.71} = 0.633$$

Abulfotouh *et al*. (2011) conducted a case-control study on 50 diabetic patients attending outpatient diabetes clinic in King Abdulaziz Medical City (KAMC) in Riyadh, who had DFD episodes between January 2009 and July 2010. The study methodology was based on testing the impact of some predictors assembled in a multiple logistic regression model on DFDs type and severity. Diabetic foot disorders studied included infection, ulceration, neuropathy, and vascular insufficiency. Significant risk factors in individual chi-square tests included male gender, age ≥40, illiteracy, DM durationn≥20y, peripheral neuropathy, PVD, IHD, and erythrocyte sedimentation rate (ESR). Applying the logistic regression with the presence of DF as the dependent variable, only neuropathy, DM duration and ESR were significant predictors for DFDs. Other variables which were significant determinants on DFDs development in separate chi square analyses were not significant predictors, in resemblance with our findings profile. A large-scale research from Denmark by Bruun and collaborates (2013) was conducted to analyze the prevalence and determinants of diabetic foot ulcers and amputation rate in adult diabetics observed over 19 years of disease diagnosis (at 6 year and 14 year observation points). Age, gender, and co-morbidities were independent variables studied. Significant predictors of any amputation were peripheral neuropathy (OR 2.09; 95% CI 1.19-3.69), vasculopathy (OR 3.43; 95% CI 1.65-7.12), male gender (OR 2.40; 95% CI 1.31-4.41). Age in women was risk of amputation, but men were at higher risk when they get DM at a younger age. In other words, age here revolve around the number of years lived with diabetes until DFDs has developed. For this very relationship, we were curious to invite to this study patients who had more eight years of enrollment with this insurer (since 2007), first to remove the confounding effect of the difference in insurance package (e.g., health benefits, preferred provider organization provision, billing and disease coding), and fluctuation on the quality of the offered health service. Second, to incorporate disease duration issue in the study background, which researchers now agreed on its role in provoking DFDs complications (Abulfotouh *et al*., 2011; Alrubean *et al*., 2015; Bruun *et al*., 2013; Reiber *et al*., 1998). With that in mind, we first tried to admit subjects with longer duration of enrollment with the insurer (10-15y). However, this was not guaranteed owing to the relative newness of this insurer in the Jeddah market (since 1997) and the restriction terms forced on release of patient information to unauthorized persons or for research purpose.

Study Aims and Answering the Research Questions

The economic burden associated with DFDs in the study population could be quantified using the dataset collected and analyzed. Results from this research, if related to the scientific and healthcare policy maker community could be of an added value in understanding and planning for improving DM the economic outcomes of diabetes and DFDs in Saudi Arabia. Likewise, the research objectives have been achieved. For instance, the distribution pattern of the study subjects' demographic traits, as well as the prevalence of DFDs intervention options have been identified and evaluated. The distribution pattern of these DFDs reflects the severity of DFDs problem in the studied population, for further action by interested healthcare planners. Specifically, the cost trends and levels linked to DFDs episodes have been thoroughly examined and quantified. The implications of the demographic and intervention correlates upon the COI have been identified and measured and inferences from the studied relationships could be concluded. Further, the predictability potential of the study variables to the change in COI could be identified and interpreted. The obtained logistic model formula enables predicting what COI category to expect (<SR35,000 or ≥SR35,000) if a diabetic patient would go through a diabetic foot experience at a certain age. Inability of the type of intervention to predict COI change does not mean they are ineffective because their effect on COI has already been shown in a separate analysis. Probably including intervention type in a larger sample size study replicating the same methodological technique of this research may well generate a significant result. The research questions have been all answered, following the same logic advocated in achieving the research objectives, as above. We now realize that 43.3% of DFDs could be treated by simple surgical intervention in the form of debridement. Less likely, meanwhile still concerning, are those who experience minor amputations (35%). This specific DFD stratum should be given top priority in the form of close follow up and observation to retain them into the less invasive DFD treatment groups. Better care and closer follow up can further improve the outcome of the two amputation groups and raise the prevalence of conservative treatment from 6.7% to tangibly higher levels in particular. Answering question about how significant the impact of demographic criteria on the prevalence of intervention options, both age and Saudi nationality have been of a significant impact with this respect (Tables 3 and 5, respectively). Inquiring about the pattern of the COI and whether there was a significant relationship between it and type of intervention, we found that COI varies significantly by intervention type, a result that can explain the most part of this research and can be used for estimating the economic burden of DFDs in the studied population. Similarly, the prediction function for COI change by any significantly included predictor was assessed using the multiple logistic technique approach, as in the methodology plan.

Strengths and Limitations

This work has a number of strengths adding to the validity and reliability of the obtained findings, e.g., planning for improved diabetes management in Saudi Arabia. The source the information was gained from is a reputed agency working in the Saudi healthcare market. From the methodology viewpoint, data entry and the sophisticated statistical analysis approach, e.g., strict adherence to PMT technique assumptions before attempting any of these techniques, enhance the validity of the study results and importantly depreciate the probability of systematic or misclassification bias. Also, in our risk-outcome analysis plan, the deployment of DFDs both aspotential risk for COI and then as an intermediary outcome enabled conducting a larger number of comparisons and helped us envisage DFDs from a broaderrisk-outcome angle. On the other hand, some limitations, which are mostly related to access to the amount of released patientdatahad been encountered. First it was not possible to get the exact duration of diabetes of the recruited patients or when it had started. Had disease duration been obtained it could have been added to the study correlates and a broader picture of the epidemiology of DFDs in Jeddah could have been drawn. The sample size we were permitted was rather small. Statistically-speaking sample size generally affects the study power due to inflating type-two error (β-error). This may often limit generalizability of studies' results. However, the quota sampling approach, which involves a nonprobability technique, could have some effect in offsetting type-2 error inflation and maintaininga better generalizability potential on the population.

Conclusion

Despite good access to health care and coverage, the incidence of amputations among our study population is worrying. Older age diabetic patients particularly the Saudis are at a greater risk for complicated DFDs and amputation. These concerns warrant developing more efficient and effective follow up policy on regular base for diabetic patients in general and DFD patients in particular. High risk patients, e.g., the obese or those with CVD and other comorbidities worth a closer follow up. The findings of this research emphasize the stressing need to keep diabetic patients under continuous glycemic control to delay the occurrence of ischemic vascular and neurological complications which in turn have serious implications upon the diabetic patient's foot wellbeing. When neglected, deranged foot vasculature and peripheral nerves act as precursors for DFDs. A preventive approach both to minimize the number of new diabetics and creating an unfavorable environment for developing complications are mostly recommended. Improving the primary prevention programs, adopting a multidisciplinary collaboration in delivering holistic healthcare service package in Saudi Arabia is critical for alleviating diabetes problems burden upon the Saudi community and the national economy. Further largerscale research highlighting other economic aspects of DFDs and utilizing evaluation techniques enabling addressing indirect costs of lost productivity, moral hazard, and impaired QOL due to loosing limbs to diabetes, is warranted particularly in population with an exceptionally high rates of diabetes, such as Saudi Arabia.

Acknowledgements

Thank you Prof. Dr. York F. Zöllner and Prof. Dr. med. Hasan A. Alzahrani who were more than generous with their expertise and precious time. A special thanks to Dr. Hani Jokhdar for his countless hours of helping to access the data, and most of all patience throughout the entire process. I would like to acknowledge and thank the Faculty of Life science, Hamburg University of Applied Sciences for allowing me to conduct my research and providing any assistance requested. Finally, I would like to thank all teachers and administrators in my Faculty that assisted me during my studying of MPH.

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