Patients-to-healthcare workers HIV transmission risk from sharp injuries, Southern Ethiopia

Biruck Desalegn, Hunachew Beyene, Ryo Yamada

Abstract

Background: Accidental needlestick injury rate among healthcare workers in Hawassa is extremely high. Epidemiological findings proved the infectious potential of this injury contaminated with a Human Immunodeficiency Virus (HIV)-infected patient's blood.

Objective: This study aimed at estimating the risk of HIV transmission from patients to healthcare workers in Hawassa City, Ethiopia.

Method: A probabilistic risk model was employed. Scenario-based assumptions were made for the values of parameters following a review of published reports between 2007 and 2010.

Parameters: HIV prevalence, needlestick injury rate, exposure rate, sero-conversion rate, risk of HIV transmission and cumulative risk of HIV transmission.

Finding: Generally, healthcare workers in Hawassa are considered to be at a relatively low (0.0035%) occupational risk of contracting HIV – less than 4 in 100,000 of healthcare workers in the town (1 in 28,751 workers a year). The 30 years' maximum cumulative risk estimate is approximately five healthcare workers per 1000 workers in the study area. Still, this small number should be considered a serious matter requiring post-exposure prophylaxis following exposure to unsafe medical practice leading to HIV infection.

Keywords: risk of HIV transmission, healthcare workers, Hawassa City

Résumé

Présentation: Le taux de blessures provoquées par des piqûres d'aiguilles chez les professionnels de la santé à Hawassa est très élevé. Des conclusions épidémiologiques ont mis en avant le potentiel infectieux d'une telle blessure contaminée par le sang d'un patient infecté par le VIH.

Objectif: L'objectif de cette étude était d'estimer le risque de transmission du VIH entre les patients et les professionnels de la santé à Hawassa, en Ethiopie.

Méthode: Une modélisation probabiliste du risque a été employée. Des hypothèses basées sur les scénarios ont été formulées pour les valeurs des paramètres suite à l'étude de rapports publiés entre 2007 et 2010.

Paramètres: Prévalence du VIH, taux de blessures par piqûres d'aiguilles, taux d'exposition, taux de séroconversion, risque de transmission du VIH, risque cumulatif de transmission du VIH.

Conclusions: D'un point de vue général, à Hawassa, les professionnels de la santé sont exposés à un risque professionnel de contracter le VIH relativement faible (0.0035%), soit moins de quatre sur cent mille professionnels de la santé dans la ville (un professionnel sur 28,751 par an). Les estimations du risque cumulatif maximum sur 30 ans sont d'environ cinq professionnels de la santé pour 100 dans la zone d'étude. Ce petit nombre devrait néanmoins être considéré comme une question grave, nécessitant une prophylaxie post-exposition suite à une exposition à une pratique médicale dangereuse conduisant à l'infection par le VIH.

Mots clés: risque de transmission du VIH, professionals de la santé, Hawassa

Biruck Desalegn is a Lecturer in the Environmental Health and has been Research Student at Kyoto University, Kyoto, Japan.

Hunachew Beyene is a Lecturer and PhD student, Public Health at Addis Ababa University, Ethiopia.

Ryo Yamada is a Professor of Medical Statistics at Kyoto University, Kyoto, Japan.

Correspondence to: biruck471@yahoo.ca

1. Introduction

Concern about the possible Human Immunodeficiency Virus (HIV) transmission during medical practice is common on account of the devastating psychosocial and health consequences (Hansen & Mclntire 1996). Each year, nearly three million healthcare workers are exposed to blood-borne viruses and approximately 90% of the acquired infections occur in low-income countries (Jovic-Vranes, Jankovic, Vukovic, Vranes & Miljus 2006; Kermode, Jolley, Langkham, Tomas & Crofts 2005). These exposures occur through needlestick injuries or cuts from other sharp instruments contaminated with an infected patient's blood or through contact of the eye, nose, mouth or skin with a patient's blood (CDC 2008).

Needlestick injuries are primarily accounted for the exposure which may result in a potential HIV infection (Wilburn & Eijkemans 2004). As a consequence, the risks of acquisition of HIV by percutaneous and mucocutaneous routes are estimated to be 0.32% and 0.03%, respectively. Depending on the risk assumed, the estimated proportion of transmission caused by contaminated injections in sub-Saharan Africa ranged from 2.5% to 30% or more (White, Cooper Ben, Kedhar, Orroth, Biraro, Baggaley, *et al.* 2007).

The healthcare workforce, worldwide, represents 12% of the working population (World Health Organization 2002). According to a time-series study by (Abraha & Nigatu 2009) in Ethiopia, the average rates of increment of nurses and physicians per year are 1000 and 150, respectively. The occupational health risk of these significant groups of workers demands both organizational and government concern.

Following the first report on the sero-conversion in a healthcare worker after occupational percutaneous exposure to HIV (Anon 1984), many countries established surveillance of healthcare workers. In sub-Saharan Africa, lack of consistent direct data and large uncertainty in the risk of HIV transmission from HIV-contaminated injections have made the quantification of the proportion of transmission caused by contaminated injections difficult and unavoidably subjective (White, Cooper Ben, Kedhar, Orroth, Biraro, Baggaley, *et al.* 2007).

Furthermore, there is some misconception existing that the healthcare industry is 'clean' and without risk, when in fact the blood-borne exposures encountered can be life-ending (Lipscomb & Rosenstock 1997). This study has the objective of estimating patients-to-healthcare workers HIV transmission risk from sharp injuries.

2. Materials and methods

2.1 Study site

This study referred to the healthcare workers in Hawassa. The town comprises 52 healthcare institutions, 5 hospitals, 2 health centers, three higher clinics, 23 intermediate and small clinics, 5 eye and dental clinics and 14 diagnostic medical laboratories (Awassa City Administration Health Department 2008).

2.2 Determinants of risk and risk estimation model

The likelihood of patient-to-physician HIV transmission from sharp injuries during a medical/clinical procedure depends on the probabilities of patient's HIV status, needlestick injuries, exposure to blood after injury and HIV sero-conversion (Prüss-Üstün, Rapiti & Hutin 2003). We reviewed reports between 2007 and 2010 for the values of these parameters. However, for verifying the values, we referred to comprehensive researches done in the region since 2004. Scenario-based assumptions were also made for the prevalence of HIV infection to suit the study purpose. Owing to the variability of medical practices among workers, we examined risk scenarios using a predictive analysis. Minimum and maximum values were used for the parameters in the model. For values with a major difference, we also considered the average value.

Therefore, the probability of HIV transmission was estimated with the following conditions:

1. *Prevalence of HIV infection* (p_i): We took the prevalence of infection among the general population in the study area. Owing to the difficulty of obtaining the true infection prevalence of patients, the study assumed various values to include all possibilities in risk estimation and averaged the following: 0.6% (national and rural), 2.3% (study region, adult prevalence) (SNNPR HIV/AIDS Forum of NGO's, January 2008 – December 2010), 3.2% (study area, rural) and 7.5% (study area, town) (Datiko, Yassin, Chekol, Kabeto & Lindtjørn 2008). Values included in the model are 0.023, 0.049 and 0.075.

2. *Needlestick injury rate in healthcare workers* (p_{nsi}): Needlestick injury was taken as an end point for the HIV infection that the healthcare workers might acquire as a consequence of being exposed to infected blood or body fluids. We used a very recently published finding that is specific to the study area, 30.9% (Tadesse & Tadesse 2010). This value is similar to the injury rate obtained in 2004 (Yoseph 2004). We considered using the minimum and maximum values of 0.24 and 0.41, respectively.

3. *Exposure rate/number of injuries leading to exposure* (p_{exp}): Exposure was defined as the probability that healthcare workers will be exposed to blood or body fluids after injury. As there is no published study conforming to these parameters, we used results from our job safety analysis, where the average annual frequency of blood contact after injury was 33%. A study by Yoseph (2004) in the district showed the high frequency and an assumption that most injuries might result in exposure. Therefore, we assumed the values of 0.33 and 0.9 in the model.

4. *Sero-conversion rate* (p_{sc}): HIV infection is generally transmitted when a healthcare worker is exposed to virus-containing blood or body fluids. The risk of acquiring HIV infection following each percutaneous exposure was taken in the range of 0.3 – 0.43% (Becker, Cone & Gerberding 1989; Henderson 1989). The values in the model were 0.003 and 0.0043.

2.3 Risk estimation for HIV transmission

The following formula was used to estimate the risk on the presumed setting values and treated as an independent event (Prüss-Üstün *et al.* 2003):

HIV risk is a function of $p_{sc} * p_{exp} * p_i * p_{nsi}$

$$\pi = p_{sc} * p_{exp} i_{nsi}, \tag{1}$$

where π is the probability that a randomly selected healthcare worker is infected with HIV. The probability of no infection is $1 - (\pi)$. After 'n' years of occupational exposure, the risk of infection is

$$1 - [1 - (\pi)]^n. \tag{2}$$

For the simulation model, we used the R statistical software.

To facilitate the risk management program, we put emphasis on few scenarios based on the values of the most recent figures.

Scenario	p_{nsi}	p_{exp}	p_i	p_{sc}
1	0.31	0.33	0.023	0.003
2	0.31	0.9	0.023	0.003
3	0.24	0.33	0.049	0.003
4	0.41	0.33	0.023	0.003
5	0.41	0.33	0.049	0.0043

2.4 Ethical consideration

This study was approved by the Ethical Committee of Hawassa University, Health Science College.

3. Results

3.1 HIV transmission risk from patients to healthcare workers

The mean estimated risk of HIV transmission from patients to healthcare workers attributable to a workplace percutaneous injury with a needle or a sharp instrument contaminated with blood was 0.0000353 ($\pm$ 0.00002753). The minimum and maximum estimated risk values under all assumed scenarios were 0.00000546 and 0.000116235, respectively. Scenario-based HIV transmission risk with respect to the year of occupation is illustrated in Fig. 1. Few selected scenarios are shown to establish the directions of intervention. In scenario 1, the chance of HIV transmission is 1 person per 10,000 healthcare workers, while for scenario 5 (under assumption of maximum injury rate and sero-conversion rate), the chance is 5 persons per 10,000 healthcare workers.

3.2 Cumulative HIV transmission risk

The 10 and 30 career average cumulative HIV risks to the healthcare workers in Awassa were 0.0007048 ($\pm$ 0.00055004) and 0.0010569 ($\pm$ 0.00082463), while the minimum and maximum cumulative risk estimates were 0.00011 and 0.00232 in 10 years and 0.00022 and 0.00464 in 30 years, respectively (Table 1).
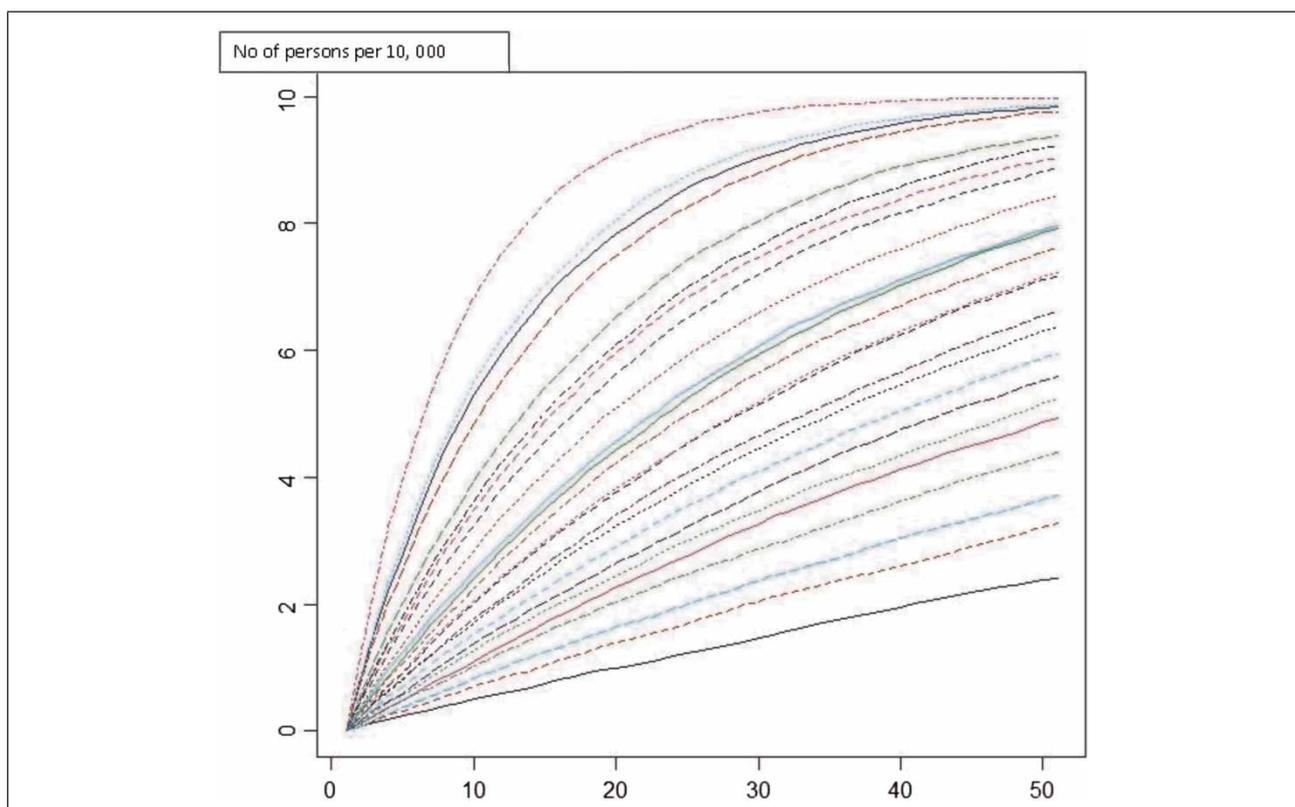

Fig. 1. Spectrum of chances of acquiring HIV infection in all assumed scenarios.

Table 1. Probability matrix for cumulative HIV transmission risk.

	HIV transmission model: $1 - [1 - (\pi)]^{n}$; where $\pi = p_{sc} * p_{exp} * p_i * p_{nsi}$			
	Parameter values			
	Max. value		Min. value	
p_{nsi}	0.24		0.41	
p_{exp}	0.33		0.9	
p_i	0.23		0.75	
p_{sc}	0.003		0.0043	
n (Occupational career)	10, 20, 30, 40			
Occupational career	Mean	Std. deviation	Minimum	Maximum
10	0.0007048	0.00055004	0.00011	0.00232
20	0.0007048	0.00055004	0.00016	0.00348
30	0.0010569	0.00082463	0.00022	0.00464
40	0.0014088	0.00109890	0.00001	0.00012

4. Discussion

Healthcare workers are at a risk of occupational acquisition of HIV infection, primarily due to an accidental exposure to infected blood and body fluids. The previous year's needlestick injury rate in the study area was 30.9% (Tadesse & Tadesse 2010). Although the needlestick injury rate is high in the study area, this study showed that the HIV transmission risk from patients to healthcare workers is fairly low (0.0035%) – less than 4 in 100,000 of healthcare workers in the town (1 in 28,751 workers a year). If the healthcare worker was known to be infected with HIV, the risk would be still lower. However, these estimates could not guarantee the risk to some healthcare workers in hospitals, such as surgeons, who perform frequent invasive medical procedures and might have their gloves frequently cut and perforated. Still, this small number should be considered a serious matter requiring post-exposure prophylaxis following exposure to unsafe medical practice leading to HIV infection.

As revealed in Fig. 2, the probability of HIV transmission in scenario 5 is higher than that in scenario 1, showing the importance of the frequency of needlestick injuries for risk evaluation. This suggests the substantial risk reduction that can be achieved by lowering the rate of needlestick injuries.

The 30 years' maximum cumulative risk estimate is approximately 5 healthcare workers per 1000 workers in the study area. Weaknesses inherent in the risk estimation and modeling are the uncertainty about some values of the prevalence of HIV infection and injury rate difference among workers. Validity of the assumptions is important for the risk calculation. Therefore, reliance on the limited available reports can bias the estimation. This study may also underestimate the HIV risk estimation as it did not take into account the healthcare workers in centers where there is a high risk of sharp injuries. Therefore, the cumulative risk value might be higher for workers in specialized clinics where there are a large number of HIV-infected patients and special circumstances such as those where healthcare workers routinely pursue emergency care for adult trauma cases. By and large, the occupational career risk of infection depends on the healthcare worker's actual exposure, changes in the pattern of HIV prevalence and precautionary measures in use before and after exposure.
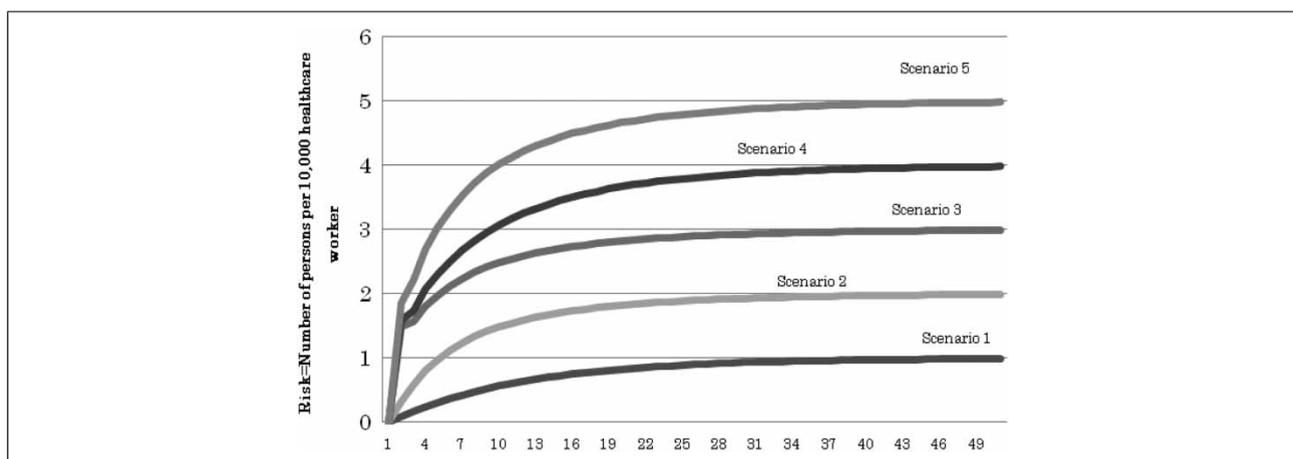

Fig. 2. Risk curve for the HIV transmission from patient to healthcare worker, Hawassa, Ethiopia.

The risk estimates of HIV infection in healthcare workers attributable to accidental needlestick injuries could be considered current as our several assumptions were based on available and timely data.

5. Conclusion

This study estimated HIV transmission risk of healthcare workers as a result of various spectra of medical/clinical practice. Although these groups of workers in Hawassa are considered to be at a relatively low risk of contracting HIV regardless of the safety of medical practice in the region, the cumulative risk to workers in specialized centers might be higher. For effective risk management practice in the healthcare system, challenging the complex role of professional values and work pressure seems to be a necessity. To reduce the incidence of needlestick injuries, a structured system of reporting injuries and targeted education and training programs on universal safety precautions for the prevention of nosocomial infections may still be necessary.

Acknowledgements

References

Abraha, M. & Nigatu, T. (2009). Modeling trends of health and health related indicators in Ethiopia (1995–2008): a time-series study. Health Research Policy and Systems, 7(29), doi:10.1186/1478–4505–7–29.

Anon (1984). Needlestick transmission of HTLV-III from a patient infected in Africa. Lancet, 324(8416), 1376–1377.

Awassa City Administration Health Department (2008). Compiled Report on Healthcare Facilities in Hawassa City, Ethiopia.

Becker, C.E., Cone, J.E., & Gerberding, J. (1989). Occupational infection with human immunodeficiency virus (HIV). Annals of Internal Medicine, 110(8), 653–656.

CDC (2008). Exposure to Blood: What Healthcare Personnel Need to Know, Atlanta, GA.

Datiko, D., Yassin, M., Chekol, L., Kabeto, L., & Lindtjørn, B. (2008). The rate of TB-HIV co-infection depends on the prevalence of HIV infection in a community. BMC Public Health, 8(7), 266, doi:10.1186/1471–2458–8–266.

Hansen, M. & Mclntire, D. (1996). HIV transmission during invasive radiologic procedures: estimate based on computer modeling. AJR, 166, 263–267.

Henderson, D.K. (1989). Perspectives on the risk for occupational transmission of HIV-1 in the health care work place. Occupational Medicine, 4(2), 7–12.

Jovic-Vranes, A., Jankovic, S., Vukovic, D., Vranes, B., & Miljus, D. (2006). Risk perception and attitudes towards HIV in Serbian health care workers. Occupational Medicine, 56(4), 275–278.

Kermode, M., Jolley, D., Langkham, B., Tomas, M.S., & Crofts, N. (2005). Occupational exposure to blood and risk of bloodborne virus infection among health care workers in rural north Indian health care settings. American Journal of Infection Control, 33(1), 34–41.

Lipscomb, J. & Rosenstock, L. (1997). Healthcare workers: protecting those who protect our health. Infection Control and Hospital Epidemiology, 18(6), 397–399.

Prüss-Üstün, A., Rapiti, E. & Hutin, Y. (2003). Sharp injuries. Global burden of disease from sharps injuries to health-care workers. Geneva, World Health Organization (WHO Environmental Burden of Disease Series, No. 3).

SNNPR HIV/AIDS FORUM of NGOs Strategic Plan (January 2008–December 2010); SNNPR HIV/AIDS Forum of NGOs, Awassa, Ethiopia.

Tadesse, M. & Tadesse, T. (2010). Epidemiology of needlestick injuries among health-care workers in Awassa City, Southern Ethiopia. Tropical Doctor, 40(2), 111–113, doi:10.1258/td.2009.090191.

White, R., Cooper Ben, S., Kedhar, A., Orroth, K.K., Biraro, S., Baggaley, R.F., et al. (2007). Quantifying HIV-1 transmission due to contaminated injections. PNAS, 104(23), 9794–9799.

Wilburn, S. & Eijkemans, J. (2004). Preventing needlestick injuries among healthcare workers. International Journal of Occupational and Environmental Health, 10(4), 451–456.

World Health Organization (2002). The World Health Report. Geneva, Switzerland, WHO.

Yoseph, W/Gebriel. (2004). Assessment of the safety of injections and related medical practice in health institutions at Sidama Sone. SNNPRS (Masters Thesis report). etd.aau.edu.et (Accessed 18 May 2010).