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DO WE ADEQUATELY RESPECT THE POTENTIAL OF ROUTINE PRIMARY HEALTH CARE SERVICES IN REDUCING NEONATAL MORTALITY IN DEVELOPING COUNTRIES? THE EXAMPLE OF THE DENIZLI COHORT

Sarp Uner[1],
Banu Çakır[1],
Kasırga Yıldırak[2]

[1] MD, PhD, Hacettepe University Faculty of Medicine
Department of Public Health
[2] Assist. Prof., Department of Economics, Trakya University & Institute of Applied Mathematics, Middle East Technical University

Do we adequately respect the potential of routine primary health care services in reducing neonatal mortality in developing countries? The example of the Denizli cohort

This study aimed to examine the burden of neonatal deaths in Denizli province, Turkey, over a 5-year period and to investigate the role of "routine" primary health care (PHC) services provided to mothers and infants by the Ministry of Health in reducing neonatal deaths, while controlling for major confounding factors.

A retrospective cohort study was conducted based on the health records of the Provincial Health Directorate of Denizli, Turkey. Data were collected from the 5-year records of a total of 119 PHC units responsible for providing comprehensive PHC services to all residents of the province. A random-effect Poisson panel regression was employed to investigate the association between "monitoring services (for mothers and babies) provided by PHC unit personnel" and the neonatal mortality.

According to the results of study the final model revealed that "monitoring", i.e., the joint factor for the average number of regular visits of the mother (during pregnancy and over puerperium) and that of the babies over the neonatal period was found to have a positive impact on decreasing the neonatal infant mortality rate. In the final model, controlling for the total number of live births in the health care service area, neonatal mortality was detected to be negatively associated with total populations per nurse, total populations per midwife, presence of prematurity and presence of low birth weight whereas having deliveries in the hospital setting decreased the risk of neonatal deaths significantly.

The findings of the study are important, revealing that the neonatal mortality rates could be decreased significantly by increasing the number of regular health visits of mothers and newborn babies to PHC units, with no need for specialized health personnel or additional costs.

Apprécions-nous suffisamment le pouvoir des services de soins de santé primaires « de routine » sur la réduction de la mortalité néo-natale dans les pays en développement ? L'exemple de la cohorte Denizli

Cette étude souhaite étudier l'intensité de la mortalité néo-natale dans la province de Denizli, en Turquie, sur une période de 5 ans et examiner le rôle des services de soins de santé primaires "de routine" fournis aux mères et aux bébés par le Ministère de la Santé afin de réduire la mortalité néo-natale, en déterminant les facteurs causaux importants.

Une étude de cohorte rétrospective a été conduite d'après les données de santé de la direction de la Santé de la Province de Denizli. Les données ont été recueillies sur une période de 5 années pour un total de 119 unités primaires responsables de la dispense de soins primaires complets à tous les résidents de la province. Un échantillon, d'après une régression en loi aléatoire de Poisson, a été constitué pour étudier le lien entre « les soins des unités de surveillance (mères et bébés) dispensés par le personnel d'unité de santé primaires » et la mortalité néo-natale.

Selon les résultats de cette étude, le modèle a révélé "que la surveillance", c'est-à-dire, le nombre moyen de visites régulières de la mère (prénatales et postnatales) et des bébés pendant la période néo-natale, avait un impact positif sur la diminution du taux de mortalité infantile néo-natale. Dans le modèle final, en retenant le nombre total de naissances vivantes dans la zone desservie en soins de santé, on a constaté que la mortalité néo-natale est négativement liée au ratio population/infirmière, population/sage-femme, ainsi que le nombre de prématurés et le nombre de naissances au poids insuffisant, alors que les accouchements dans un cadre hospitalier diminuent le risque de mortalité néo-natale de façon significative.

Les conclusions de l'étude sont importantes, révélant que les taux de mortalité néo-nataux pourraient être diminués de façon significative en augmentant le nombre de visites de santé régulières des mères et des nouveau-nés dans les unités des soins de santé primaire, sans besoin d'un personnel de santé spécialisé ni de coûts supplémentaires.

I- Introduction

Child health is a core public health issue globally. The Millennium Development Goal (MDG) 4 to reduce under–5 mortality by two-thirds by the year 2015 is critically dependent on a substantial reduction in neonatal mortality over the next decade. It is apparent that a disproportionate burden of infant and under-5 childhood mortality relates to deaths within the first month of life, i.e., the neonatal period, which frequently occur within the first few days after birth. Every year, 4 million babies (37% of under–5 deaths) die in the neonatal period. Globally, the three major causes of death in the first month of life include problems due to pre–term birth, severe infections (mainly pneumonia/sepsis) and problems related to complications during childbirth (1). Of the 10 million children dying every year, nearly 3 million of these babies can be saved with low–tech, low–cost interventions, which can also save the lives of mothers and avoid stillbirths (2, 3).

The majority of neonatal deaths occur in developing countries. Appropriate neonatal care in any given circumstance in developing countries requires an integrated and holistic program of interventions at various levels, including not only health-related interventions with direct bearing on perinatal and/or neonatal outcomes but via improvements in the life status of women and children in general (4). Thus, reduction in neonatal mortality is generally considered a "tough" task compared to reduction in postneonatal mortality, which is often responsive to less sophisticated and easier interventions such as routine vaccination, balanced and healthy nutrition, use of oral rehydration for diarrhea, early diagnosis and treatment of infections, and preventiive measures against injuries. This perception, unfortunately, may underestimate the "potential" of routine primary health care (PHC) services in reducing neonatal mortality, particularly in developing countries.

Human resources play a critical role in delivering health services to the population. In the context of the MDGs, human resources for health pose a new challenge for health policy- and decision-makers in countries, and the question of having "the right number, the right skills and the right distribution of health workers" to meet the MDGs is one with which many governments are struggling (5). These issues are of higher importance when PHC is of concern, given that PHC services should have a comprehensive coverage, be easily accessible and acceptable, and should incorporate focused community-based intervention packages based on national/local needs.

This study aimed to examine the burden of neonatal deaths in Denizli province, Turkey, over a 5-year period and to investigate the role of "routine" PHC services provided to mothers and infants by the Ministry of Health in reducing neonatal deaths, while controlling for major confounding factors. The ultimate goal is to provide data for the policy-makers to evaluate the role (if any) of routine (basic) PHC services in decreasing neonatal mortality, without a need for further sophisticated neonatal units, neonatology specialists, specialized care instruments, etc., so that future human resources planning (re: number, distribution, skills, on-job training) can be based on scientific evidence and PHC personnel will be motivated and encouraged in providing effective services for mothers and infants residing in their service areas.

2- Material and method

A retrospective cohort study was conducted based on the health records of the Provincial Health Directorate of Denizli, Turkey for the 5-year period from 1999 through 2003. Data were collected from the 5-year records of a total of 119 PHC units responsible for providing comprehensive PHC services to all residents of the province. Health records in the province were standardized, and health-related data had been collected routinely on a monthly basis, further merged at the provincial level,

throughout the study period. A standardized data collection form was prepared for the purposes of the study, and data extraction from provincial records was completed by a physician experienced in health administration.

Statistical analyses in the study included distribution of counts and percentages of various health conditions by individual PHC units, calculation of specific rates for health service areas of individual health units, and further modeling of neonatal mortality in the province to investigate its association with regular "monitoring" of the babies (in prenatal, neonatal and postnatal periods) and their mothers (in prenatal period and over puerperium), while controlling for potential confounders.

2.1 Specific Issues Regarding Data Analysis

The main outcome of interest in the study was neonatal mortality. In the modeling of neonatal mortality, Y was considered as a random variable taking the values 0 and 1, with 1 indicating the state of neonatal death, i.e. death of a liveborn baby over the first 28 days of life. In the model, probability of neonatal death was calculated as:

$$\Pr(d) = \frac{\exp(-\lambda)\lambda^d}{d!},$$

where d is the cumulative sum of Y in n number of observations (i.e., number of neonatal deaths in the study). It is assumed that d follows a Poisson distribution with parameter λ, and for a potential risk factor of X, log of expectation of X (1) is linearly regressed on linear combination of explanatory variables, weighted with coefficients. In other words:

$$\log(E[d \mid X]) = \log(n) + X\beta \quad (1)$$

2.2 Use of Poisson Regression for Modeling Neonatal Mortality

In the linear model of Poisson regression:

$$Y_{it} = \alpha + X_{it}\beta + u_{it},$$

i denotes the cross-section dimension (characteristics and services provided by individual health units), t denotes the time series dimension, α is a scalar, and β is K by 1 vector of coefficients and it^{th} observation on K explanatory variables. In the model, there are two error terms:

$$u_{it} = \mu_i + \nu_{it} \quad (2),$$

where, μ_i denotes the unobservable individual-specific effect and ν_{it} denotes the remainder disturbance. μ_i is time invariant and accounts for any health care unit-specific effect that is not included in the regression (6).

In the study, the health care unit-specific effect could have been modeled as "fixed" or "random". The "fixed effect" model uses dummies assigned to the individual cases, in this case to individual health care units (n=119). If an unobservable explanatory variable is specific to one health care unit/specific population the health care unit provides service for, this variable is left out or unobservable, yet the fixed effect model would account for the omitted variable. However, the fixed effect model introduces too many variables to the regression, assuming a complete measurement on observations, which could not be confirmed for the study population. The Hausman specification test was used for choosing an appropriate model for the data, and a random effect model was selected, assuming sampling from a larger population and treating μ_i as a random variable (6, 7).

Primary health care units are responsible of providing routine visits for babies and mothers, with increased frequency over pregnancy, puerperium and in infancy. The timing of visits is arranged such that both the baby and the mother can be observed/examined simultaneously at any time either of them requires special care (such as at the times of vaccinations, on the 15^{th} and 40^{th} days following delivery, etc.). Additionally, it is known that health evaluation and care for the mother directly influences the health of the baby. Given that monitoring activities of the mother and baby can not be considered separately and both are important for the health of the infant, in this study, monitoring of babies (and mothers) was studied as a "joint" outcome of several health care activities provided for the mother and the baby together and/or separately (such as home visits by midwives, regular check-ups by physicians, vaccination by nurses, etc.).

To investigate the joint effect of all such factors, we dealt with a panel data, and used the panel version of Poisson regression in modeling. A factor was created as a linear combination of the average number of monitorings for babies (AMB) and average number of monitorings for mothers (AMM), using the principal component method, designated as the "monitoring factor" and treated as the main exposure of interest in the study, with an attempt to investigate its association with neonatal mortality, while controlling for other potential risk factors and/or confounders.

For the panel version of Poisson regression, we used the following equation (8):

$$\log \lambda_{it} = \log(n_{it}) + X_{it}\beta \quad (3)$$

In accordance with equation (1), the independent variable is the logarithm of the neonatal death count, and logarithm of the number of total births is located on the right side of the equation as the main exposure in Poisson regression (i.e., the population at

risk from which neonatal deaths could have arisen). In order to eliminate any scaling or collinearity problems, some of the potential confounders were transformed: Total populations per physician (PPP), per nurse (PPN) and per midwife (PPM) were all standardized. PPP was dropped from the model because it was not a statistically significant predictor of neonatal mortality *per se* (i.e., p-value was high). In analysis, the number of deliveries performed in the hospital setting, the rate of low-birth-weight babies (LBWBs) and the premature birth rate were all divided by 100 to overcome possible problems arising due to scaling.

In summary, a random-effect Poisson panel regression was employed to investigate the association between "monitoring services (for mothers and babies) provided by PHC unit personnel" and the neonatal mortality. The variable "monitoring" was created as a linear combination of the average number of visits in pregnancy and the average number of visits over infancy. The final model presented represents the most parsimonious yet statistically significant, factors for neonatal mortality. For each variable of interest, the incident rate ratio (IRR) of neonatal mortality associated with the presence of the given factor was an exponent of fitted coefficients on the confounders: $\exp(\hat{\beta}_j)$.

3- Results

For the purposes of the study, data were gathered on the number of health personnel, total number of the population at risk, number of live births, number of premature babies, number of LBWBs, number of neonatal deaths, and also the total number of visits for each pregnant woman and newborn baby (throughout infancy).

As the first step in analyses, the average number of visits through pregnancy was calculated for each health care unit in the province. Similarly, the average number of health visits of each

baby (over the first 365 days of life) was calculated for each of the 119 health units studied, for the period 1 January 1999 - 31 December 2003. The proportion of births in the hospital setting was calculated by dividing the number of births in hospital by the total number of live births in that health care jurisdiction area in a given year.

Table 1
Distribution of various selected health measures by years, Denizli province, Turkey*

		Years				
		1999	**2000**	**2001**	**2002**	**2003**
Population	Total	800386	810879	821881	834570	847417
	15–49-year-old women	218417	219319	224631	227613	231965
	0–11–month-old infants (% in total population)	14252 (1.8%)	14091 (1.7%)	13991 (1.7%)	12702 (1.5%)	12389 (1.5%)
	Population increase rate %0	12.5	12.5	12.6	10.8	10.3
Human resources	Number of physicians	244	257	253	253	271
	Total number of population per physician	3039.8	3068.3	3248.5	3248.5	3127.0
	Number of health officers	138	115	116	116	124
	Total number of population per health officer	5374.7	6857.1	7085.2	7085.2	6834.0
	Number of nurses	274	257	281	281	316
	Total number of population per nurse	2707.0	3068.3	2924.8	2924.8	2681.7
	Number of midwives	602	605	643	643	681
	Total number of population per midwife	1232.1	1303.4	1278.2	1278.2	1244.4
Outpatient services	Average number of visits to PHC outpatient clinic per population per year	1.5	1.6	1.8	1.6	1.7
	Referral rate (% of individuals referred from PHC units to higher health care facilities)	8.8	8.6	8.4	9.6	11.5

*Data were gathered from 5-year records of 119 PHC units, covering the entire population in the province. The health indices provided in the table represent the range (min-max) of measures obtained in the province in a given year, based on data from all 119 units.

Over the 5-year study period, the population growth rate in the province ranged between 10.3% (2003) - 12.6% (2001), with a

gradual decrease over time (Table 1). Over the same period, the proportion of infants (0-11 months) in the total population ranged between 1.5-1.8%. The total number of PPP, PPN and PPM varied slightly over the years, yet did not show any significant change/pattern. The total number of population per health technician seemed to increase over the years, which could at least be partially explained by the changes in job descriptions and/or added responsibilities in localities experiencing health care personnel shortages. The average number of admissions to a PHC facility for (any) examination ranged between 1.5 (1999) to 1.8 (2001) annually, whereas the referral rate increased significantly from 8.8% to 11.5%, with a peak value in 2003. It was not possible to distinguish the proportion of routine/check-up visits versus visits for various symptoms, nor to estimate the proportion of multiple visits of the same individuals (such as of diabetics or hypertensives for prescriptions, lab tests, etc.). The increase in referral rates over the years compared to almost a similar number of visits per year may suggest that the slight increase in admission rates was more likely to represent disease/symptom-based visits rather than those of healthy individuals, or it could be due to a change in patient mix, with increasing use of PHC facilities for complex diseases (Table 1).

Table 2
Distribution of various maternal and child health measures by years, Denizli province, Turkey*

		Years				
		1999	**2000**	**2001**	**2002**	**2003**
Fertility	Number of live births	12954	13141	13358	12103	11856
	Crude birth rate (per 1000)	16.2	16.2	16.3	14.5	14.0
	General fertility rate (per 1000)	59.31	59.9	59.5	53.2	51.1
	Abortion rate (per 1000)	48.1	52.3	56.7	60.9	86.1
	The number of births with weight <2500 g (% of all live births)	208 (1.6%)	252 (1.9%)	253 (1.9%)	240 (2.0%)	267 (2.3%)
	Number of premature births (% of all live births)	230 (1.8%)	244 (1.9%)	314 (2.4%)	227 (1.9%)	237 (2.0%)
Mortality	Maternal death rate (per 10000)	5.4	6.8	5.2	5.0	4.2
	Number of infant deaths (0–28 days)	148	179	163	129	114
	Neonatal death rate (per 1000)	11.4	13.6	12.2	10.7	9.6
	Number of infant deaths (29–364 days)	88	96	91	82	72
	Postneonatal death rate (per 1000)	6.8	7.3	6.8	6.8	6.1
Average number of health visits	Of 15-49-year-old women	1.3	1.5	1.8	2.0	1.9
	Over pregnancy	4.9	5.0	5.9	6.0	6.0
	In postpartum period	2.3	2.4	2.7	2.8	2.8
	Of the baby over infancy	7.8	7.5	8.5	8.9	8.7
Place of birth	Hospital (%)	89.4	91.5	92.4	93.5	95.7
	With the help of health personnel	9.0	7.0	6.1	5.0	3.2
	At home - without assistance (%)	1.6	1.5	1.5	1.5	1.1

* Data were gathered from 5–year records of 119 PHC units, covering the entire population in the province. The health indices provided in the table represent the range (min-max) of measures obtained in the province in a given year, based on data from all 119 units.

Maternal and child health-related indices over the 5 years suggested an improvement in services, in general: Crude birth rate and general fertility rate decreased over time, suggesting

improved family planning services. Maternal deaths decreased significantly, from 5.4/10 000 in 1999 to 4.2/10 000 in 2003. In parallel, the proportion of hospital deliveries increased, with a similar decrease in deliveries without assistance of health personnel. The decrease in neonatal mortality was more significant than the decrease in postneonatal mortality. This finding was consistent with the steady increase in the number of health care visits over pregnancy, during the postpartum period and over infancy. The slight yet steady increase in the average number of visits of 15-49-year-old women on a annual basis was also likely to support the improvement in neonatal mortality rates over time through its direct effects on women's health (Table 2). As important risk factors of the neonatal mortality rate, the proportion of LBWBs and premature births did not change significantly over time. This suggests that the improvement in neonatal deaths may be due to an increase in the "quality of services", rather than a significant decrease in populations at high risk (for neonatal mortality). This issue can not be investigated further based on the routine recording system.

The abortion rates, in contrast, seemed to increase over time. It was beyond the scope of this study to distinguish the precentage of abortions due to high-risk pregancies and those due to unwanted pregnancies. Thus, the potential association between the decrease in neonatal mortality and the increase in abortion rates could not be studied further.

Factors associated with the neonatal mortality rate were studied using Poisson regression, where the dependent variable was neonatal death counts **(Table 3)**. The final model revealed that "monitoring", i.e., the joint factor for the average number of regular visits of the mother (during pregnancy and over puerperium) and that of the babies over the neonatal period was found to have a positive impact on decreasing the neonatal infant mortality rate. In the final model, controlling for the total number of live births in the health care service area, neonatal mortality was detected to be negatively associated with PPN (IRR= 1.02,

95% confidence interval [CI]= 1.01 – 1.02), PPM (1.02, 95% CI= 1.01 – 1.02), presence of prematurity (IRR= 2.52, 95% CI= 2.47 – 2.55), and presence of LBW (IRR= 1.06, 95% CI= 1.04 – 1.07), whereas having deliveries in the hospital setting decreased the risk of neonatal deaths significantly (IRR= 0.85, 95% CI= 0.79 – 0.90). Variance of alpha (μ_i in equation (2)) was quite small, indicating that there is no statistically significant difference across health care units regarding unit-specific characteristics. With all these variables in the model, "monitoring" (of the mother and the infant) was seen to be statistically significantly associated with neonatal mortality. When the "monitoring factor" is increased by one unit, IRR for **neonatal counts** would be expected to decrease by a factor of 0.784, holding all other variables in the model constant.

Table 3
Poission modeling of the neonatal mortality rate

Variable	IRR*	Std. Error	Z-value	P-value	95% CI for IRR*
"Monitoring" (of the mother and the baby)	0.7844	0.0024	-76.47	<0.01	0.77 - 0.78
Population per nurse	1.0151	0.0023	6.50	<0.01	1.01 – 1.02
Population per midwife	1.0184	0.0020	9.06	<0.01	1.01 – 1.02
Birth at hospital (yes vs. no)	0.8490	0.0261	-5.32	<0.01	0.79 – 0.90
Prematurity (yes vs. no)	2.5102	0.0201	114.41	<0.01	2.47 – 2.55
Low birth weight (yes vs. no)	1.0579	0.0085	6.94	<0.01	1.04 – 1.07
Total live births (counts)	Exposure (population at risk)				
Ln alpha	0.2083	0.1254			-0.03 – 0.45
Alpha	1.2316	0.1544			0.96 – 1.57

*IRR: Incidence Rate Ratio, CI: Confidence Interval
Log likelihood = -236300.23 p<0.0001

4- Discussion

Although rates vary significantly across nations, neonatal mortality is an important public health problem globally, and

each nation endeavors to reduce its rates as its resources permit. The proportion of deaths that occur in the neonatal interval varies systematically according to the overall rate of mortality. In populations with the highest child mortality rates, just over 20% of all child deaths occur in the neonatal period, but in countries with mortality rates lower than 35 per 1000 livebirths, more than 50% of child deaths were in neonates (2). Summary findings of 47 demographic and health survey (DHS) data sets from 1995–2003, corresponding to 10 048 total neonatal deaths, revealed that the majority of neonatal deaths occur over the first 24 hours of life and decrease in number as time passes. Preference for reporting certains days (such as 7, 14, 21 and 30) apparently causes some slight peaks over the time axis (2).

Black et al. reported that the major direct causes of neonatal deaths globally are infections (36%), preterm birth (28%) and asphyxia (23%). About 60–80% of neonatal deaths arise in LBWBs, while LBWBs constitute only about 14% of children born. LBWBs account for 60–80% of neonatal deaths. LBW arises through short gestation (preterm birth) or *in-utero* growth restriction, or both. Attempts to reduce the proportion of babies born with LBWs at the population level, in general, have been met with little success. However, the majority of such deaths can be prevented with extra attention to warmth, feeding and prevention or early treatment of infections, without a need for complex technology (2).

Maternal health and health care are also important determinants of neonatal survival. Complications during labor are an important determinant of fetal and neonatal survival and health. In general, intrapartum risk factors are associated with greater increases in the risk of neonatal death than those identified during pregnancy (2).

It is a frequent misperception that routine health care activities are primarily preventive on postnatal deaths, in developing countries in particular, and that prevention of neonatal deaths

requires more sophisticated health interventions targeting mothers and children alike, focused on major risk factors based on local needs. On the contrary, there is ample evidence that primary care services, well-tailored to local needs, could be quite effective in reducing neonatal deaths.

The Integrated Management of Childhood Illness strategy, as led by UNICEF in countries with infant mortality rates above 40/1000, has three components: 1) Improvement in health worker skills, 2) improvement in health systems and 3) improvement in family and community practices (9, 10). For effective improvement strategies, the baseline status of services should be evaluated carefully to lead policy makers to work on unmet needs.

This study aimed to investigate the current status of neonatal deaths and related risk factors in a selected province in a developing country and to further study if/how PHC services alone affect the burden of neonatal deaths.

There have been a number of studies reporting that PHC services are directly associated with child mortality, including neonatal deaths. Macinko et al. (2009) assessed 36 peer-reviewed studies of the impact of PHC on health outcomes in low- and middle-income countries, and showed that it has a positive role in population health over time (11). It has been shown several times that effective community-based intervention packages improve neonatal outcomes and decrease neonatal deaths by increasing referrals to health facilities for pregnancy-related complications, improving rates of early breastfeeding, etc. (12).

Systematic reviews show that access to various community-based health services reduces neonatal mortality (3). There is evidence to show that 41-72% of newborn deaths could be prevented by interventions such as tetanus toxoid immunization to mothers; clean and skilled care at delivery; newborn resuscitation; prevention of hypothermia; exclusive

breastfeeding; clean umbilical cord care; and management of pneumonia and sepsis (13).

The Safe Motherhood Initiative has successfully stimulated great interest in reducing maternal and infant mortality. Safe Motherhood begins with a healthy environment (women's status, political commitment, and socioeconomic development), which is influenced by women's health and nutritional status, reproductive and health behavior, and access to family planning and maternal care services. Provision of a safe motherhood would directly affect the babies delivered by such mothers (14). In one study, Srinivasa and Venkatesh used the maternal care receptivity (MCR) scoring system based on: 1) time of commencement of antepartum care; 2) number of antenatal clinic visits; 3) tetanus toxoid immunization; and 4) place of and person attending delivery. They found that the MCR scores are inversely associated with perinatal and neonatal mortality rates and that the two rates were three-times lower among babies born to mothers with high MCR scores compared to those with poor MCR scores (15). A similar longitudinal study on 212 pregnant women revealed that no neonatal deaths occurred in women with high MCR (16).

The majority of such maternal-child health promotion-related interventions are within the scope of PHC services and should be encouraged. At the global level, the neonatal mortality rate is consistently higher and the coverage of skilled care consistently lower in rural settings and in developing countries, in particular. Therefore, the "potential" of PHC services in reducing neonatal mortality is of much greater importance in rural settings.

At the heart of each and every health system, the workforce is central to advancing health. There is ample evidence that worker "numbers" and "quality" are positively associated with immunization coverage, outreach of primary care, and infant, child and maternal survival. The central role of human resources in the improvement of the health sector is increasingly

recognized with a particular focus on planning, training, staff retention, scopes of practice of the staff, and human resources management. Confirming our findings at the global level, it is now widely accepted that the dire shortage of health workers in many places is among the most significant constraints to achieving the three health-related MDGs to reduce child mortality (17). Individual assessment of the effects of health personnel on neonatal mortality in our study revealed that nurse and midwife densities (numbers of PPN and PPM, respectively) were significantly associated with neonatal mortality, but doctor density (PPP) was not. This finding is in accordance with the literature knowledge and could be due to the fact that, at the primary care level, nurses and midwives are primarily responsible for maternal care, and thus, their densities are likely to affect neonatal mortality significantly.

The assessment of the quality of services provided by health personnel is equally important as their number and distribution, but this was beyond the scope of our study. Yet, it is important to note that the quantity of services *per se* was found to be significantly associated with neonatal mortality in Denizli.

4.1.Strengths of this Study

The findings of the study are important, revealing that the neonatal mortality rates could be decreased significantly by increasing the number of regular health visits of mothers and newborn babies to PHC units, with no need for specialized health personnel or additional costs. Neonatal deaths are usually due to congenital anomalies, delivery-related problems, maternal diseases, etc., and are thus considered as "hard issues" in maternal-child health care. It is obvious, on the other hand, that some of these problems can easily be detected during regular maternal/child visits and that infants could be referred to specialized units in a timely manner, while timely parental consultation may ease the lives of parents and families.

4.2. Limitations of the Study

The retrospective nature of the study limits our ability to check for the confounding effect of various other factors that could not be obtained from official records, such as visits to private physicians, traditional methods used to overcome health problems that might arise in the first month of life, duration of breastfeeding, number of siblings, etc., which may interfere with the care of the babies and/or their survival probability.
The main limitation of this study is the evaluation of the role of human resources on reducing neonatal mortality using "the frequency of monitoring", which is actually an outcome composed of "availability, accessibility and acceptability", as a surrogate measure for human resources. This hinders our ability to further distinguish individual effects of availability/accessibility and acceptability.

One related issue is the fact that mothers and infants obtain health care from various sources outside PHC services provided by the Ministry of Health, such as services provided by municipalities, private physicians, outpatient clinics of government and/or university hospitals, military clinics, etc. Thus, the presence and frequency of monitoring used in our study does not represent the complete "actual monitoring/care" of the mothers/babies over pregnancy and/or after birth.

This study did not reveal any statistically significant difference across health care units regarding unit-specific characteristics. Yet, the comprehensiveness and quality of care (besides the number of visits) may or may not be similar across health units. Mothers and/or babies might have received health care from private physicians or secondary/tertiary health institutions within or outside Denizli. Similarly, health recording system quality may vary across individual care settings. Use of a random-effect model and controlling for health care-specific characteristics were aimed to minimize such effects in the study, but such a possibility can not be ruled out. Furthermore, given that there is

no absolute evidence that individuals receiving routine services from PHC facilities will be more likely to obtain additional maternal/child health care from other health facilities compared to their counterparts who do not receive routine services, we would expect to have a nondifferential misclassification bias in the study, if any. In other words, the finding of a negative association between "monitoring" and neonatal mortality in the study population seems to be "real", if not underestimated.

In conclusion, maternal and child care is a vital responsibility and service area of PHC and needs to be improved by all means possible. There seems to be a potential in Denizli province for reducing neonatal deaths simply through regular check-ups of mothers (over pregnancy, during delivery and over puerperium) and infants, via only a quantitative increase in the number of visits. The higher the quality of such services, the better would be the reductions in mortality. Further studies in heterogeneous populations are clearly warranted to provide scientific evidence regarding the role of PHC services in infant health, and such studies should be better enriched by related qualitative research.

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